हरियाणा केंद्रीय विश्वविद्यालय
CENTRAL UNIVERSITY OF HARYANA
NAAC ACCREDITED 'A' GRADE UNIVERSITY

MINUTES

36th meeting of the Academic Council

Date: 07/10/2022 at 11:00 AM

Venue: Conference Room, Administrative Block, CUH

The 36th meeting of the Academic Council of the Central University of Haryana was held on October 07, 2022 at 11:00 A.M. in the Conference Room, Administrative Block, Central University of Haryana in blended mode.

The following members attended the meeting:

1. **Prof. (Dr.) Tankeshwar Kumar, Vice Chancellor - Chairperson**
2. Prof. Sushma Yadav, Pro-Vice-Chancellor, CUH
3. Prof. Raj Kumar - (Online Mode)
4. Prof. (Dr.) Param Jeet Singh - (Online Mode)
5. Prof. B.B. Goel - (Online Mode)
6. Prof. P.C. Pattnaik - (Online Mode)
7. Dr. (Mrs.) Shimla - (Online Mode)
8. Dr. Annapoorni Subramanian - (Online Mode)
9. Prof. Suresh Kumar - (Online Mode)
10. Dr. Narender Hooda - (Online Mode)
11. Dr. P.K. Khurana - (Online Mode)
12. Prof. Sathans
13. Prof. Sarika Sharma
14. Prof. Rajesh Kumar Malik
15. Prof. Neelam Sangwan
16. Prof. Anand Sharma
17. Prof. Vinod Kumar
18. Prof. Phool Singh
19. Prof. Pawan Kumar Maurya
20. Prof. Dinesh Kumar Gupta
21. Dr. Monika
22. Dr. Bijender Singh
23. Dr. Ramesh Kumar

24. Dr. Dinesh Kumar
25. Dr. Rajesh Kumar Dubey
26. Prof. Vikas Garg
27. Prof. Surender Singh
28. Prof. Rajesh Kumar Gupta
29. Prof. Suneel Kumar
30. Dr. Ranbir Singh
31. Dr. Vishwanand Yadav
32. Prof. Ranjan Aneja
33. Dr. J.P. Bhukar (I/C Head)
34. Dr. Rakesh Kumar
35. Dr. Rajendra Parsad Meena
36. Dr. Keshav Singh Rawat
37. Dr. Mona Sharma
38. Dr. Kanti Prakash Sharma
39. Dr. Kapil Kumar
40. Dr. Jitendra Kumar
41. Prof. Harish Kumar
42. Prof. Parmod Kumar
43. Prof. Gunjan Goyal
44. Prof. Ajay Kumar Bansal
45. Dr. Payal Kanwar Chandel
46. Dr. Manoj Kumar Singh
47. Dr. Dharam Pal Punia
48. Dr. Samiksha Godara
49. Dr. Ravinder Kaur
50. Dr. Santosh C. Hulagabali, Librarian
51. Prof. Dinesh Kumar, Dean (Academic) (Special Invitee)
52. Prof. Ranvir Singh (Special Invitee)
53. Prof. Rajiv Kaushik, COE (Special Invitee)
54. **Dr. Sunil Kumar, Registrar** - **Secretary**

The following members could not attend the meeting due to prior preoccupations and were granted leave of absence: -

1. Dr. Markanday Ahuja
2. Prof. Ram Singh
3. Dr. Ashwani Mahajan
4. Prof. Chanchal Kumar Sharma
5. Dr. Ashok Kumar

At the outset the Chairman, Academic Council, extended hearty welcome to all the esteemed members of the Academic Council. He informed the House that as the last meeting of the House held just on 15-09-2022, no specific things to mention except the inauguration of **Dr. Ambedkar Centre of Excellence (DACE)** which will impart Coaching for UPSC aspirants of SC Category, allotment of Data Centre for Advance Computing to be used for Research activities by the various Departments of the University.

He also shared with the House that the admission process to UG/PG programmes of the University is going on smoothly and Ph.D. Entrance Examination has already been conducted and interviews are scheduled from 17th October onwards.

He then welcomed Prof. Sushma Yadav who has joined the University as Pro-Vice-Chancellor and extended her good wishes on behalf of the Academic Council of the University. Thereafter the agenda items were taken up for deliberation:

Item No.	DESCRIPTION
36.1	Confirmation of the Minutes of the 35th meeting of the Academic Council held on 15.09.2022. **(Minutes already circulated)** **<u>Resolution Passed:</u>** The Minutes of the 35th meeting of the Academic Council held on 15.09.2022 were confirmed.
36.2	To report, record and confirm the action taken on the resolutions of the 35th meeting of the Academic Council held on 15.09.2022. **(Annexure-I)** **<u>Resolution Passed:</u>** The action taken on the resolutions of the 35th meeting of the Academic Council held on 15.09.2022, were reported, recorded and confirmed.
	<u>ITEMS FOR CONSIDERATION</u>
36.3	To consider the recommendations of the Board of Studies of the Department of Mathematics dated 10-05-2022 & 06-09-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of 5-year integrated B.Sc.-M.Sc. (Mathematics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, for the students of batch 2021-26 (3-6 semesters). **(Annexure-II)** **Resolution:** The Council approved the Scheme and syllabi along with course on Indian Knowledge System (IKS) presented by School of Basic Sciences applicable to all the departments of School. The syllabus of IKS be circulated to all members for record.
36.4	To consider the recommendations of the Board of Studies of the Department of Mathematics dated 10-05-2022 & 06-09-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of 5-year integrated B.Sc.-M.Sc. (Mathematics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23 (1-6 semesters). **(Annexure-III)** **<u>Resolution Passed:</u>** Approved

36.5	To consider the recommendations of the Board of Studies of the Department of Geog. phy dated 24-08-2022 and School Board of School of Basic Sciences dated 12.09.2022, for the Scheme and Syllabi of M.Sc. (Geoinformatics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. Academic Session 2022-2023. **(Annexure-IV)** **Resolution Passed:** Approved
36.6	To consider the recommendations of the Board of Studies of the Department of Physics and Astrophysics dated 08-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of 5-year integrated B.Sc.-M.Sc. (Physics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, for the students of batch 2021-26. **(Annexure-V)** **Resolution Passed:** Approved
36.7	To consider the recommendations of the Board of Studies of the Department of Physics and Astrophysics dated 08-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of 5-year integrated B.Sc.-M.Sc. (Physics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-VI)** **Resolution Passed:** Approved
36.8	To consider the recommendations of the Board of Studies of the Department of Physics and Astrophysics dated 08-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi M.Sc. (Physics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-VII)** **Resolution Passed:** Approved
36.9	To consider the recommendations of the Board of Studies of the Department of Physics and Astrophysics dated 08-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of Ph.D. programme, w.e.f. the Academic Session-2022-23. **(Annexure-VIII)** **Resolution Passed:** Approved
36.10	To consider the recommendations of the Board of Studies of the Department of Chemistry dated 06-09-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of M.Sc. (Chemistry) programme, as per the CBCS, NEP-2020 and Learning

	Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-IX)** **Resolution Passed:** Approved
36.11	To consider the recommendations of the Board of Studies of the Department of Chemistry dated 06-09-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme for first three years and syllabi for second year of 5-year integrated B.Sc.-M.Sc. (Chemistry) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, for the students of batch 2021-26. **(Annexure-X)** **Resolution Passed:** Approved
36.12	To consider the recommendations of the Board of Studies of the Department of Chemistry dated 06-09-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi for first three years of 5-year integrated B.Sc.-M.Sc. (Chemistry) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XI)** **Resolution Passed:** Approved
36.13	To consider and approve inclusion of independent Ph.D. guidance of DST INSPIRE FACULTY and UGC-FRC Faculty. **(Annexure-XII)** **Resolution Passed:** It is resolved that the DST INSPIRE FACULTY and UGC-FRC Faculty may be considered as Supervisor for Ph.D. supervision as per the provisions of the relevant Ordinance related to the Ph.D. programme. However, It should be sent to UGC for clarification and inclusion in guidelines.
36.14	To consider the recommendations of the Board of Studies of the Department of Statistics dated 10-05-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of M.Sc. (Statistics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XIII)** **Resolution Passed:** Approved
36.15	To consider the recommendations of the Board of Studies of the Department of Statistics dated 10-05-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of Ph.D. (Statistics) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XIV)** **Resolution Passed:** Approved

36.16	To consider the draft Guidelines for University Research Fellowship (URF), as recommended by the Committee constituted to frame the guidelines for Non-NET Fellowship. **(Annexure-XV)** **Resolution Passed:** Approved
	Under Any other Item
36.17	To consider the recommendations of the Board of Studies of the Department of Microbiology dated 24-05-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of Ph.D. (Microbiology) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XVI)** **Resolution Passed:** Approved
36.18	To consider the recommendations of the Board of Studies of the Department of Biotechnology dated 28-06-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of Ph.D. (Biotechnology) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XVII)** **Resolution Passed:** Approved
36.19	To consider the recommendations of the Board of Studies of the Department of Biochemistry dated 17-05-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of Ph.D. (Biochemistry) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XVIII)** **Resolution Passed:** Approved
36.20	To consider the recommendations of the Board of Studies of the Department of Environmental Studies dated 30-05-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of Ph.D. (Environmental Science) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XIX)** **Resolution Passed:** The Council authorised the Vice-Chancellor to approve the scheme and syllabi.
36.21	To consider the recommendations of the Board of Studies of the Department of Pharmaceutical Sciences dated 13-05-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of M.Pharm. (Pharmacology)

	programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XX)** **<u>Resolution Passed:</u>** Approved.
36.22	To consider the recommendations of the Board of Studies of the Department of Pharmaceutical Sciences dated 13-05-2022 and School Board of School of Interdisciplinary and Applied Sciences dated 04-10-2022, for the scheme and syllabi of M.Pharm. (Pharmacognosy) programme, as per the CBCS, NEP-2020 and Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-XXI)** **<u>Resolution Passed:</u>** Approved
36.23	To consider the adoption of the University Grants Commission "**Guidelines for Higher Educational Institutions to offer Apprenticeship/Internship embedded Degree Programme.**" **(Annexure-XXII)** **<u>Resolution Passed:</u>** Approved.
36.24	To consider the adoption of the University Grants Commission "**Guidelines for engaging Professor of Practice in Universities and Colleges.**" **(Annexure-XXIII)** **<u>Resolution Passed:</u>** Approved.
36.25	To consider the adoption of the University Grants Commission "**Guidelines for Admission and Supernumerary seats of International Students in Undergraduate and Postgraduate Programmes in Higher Educational Institutions in India.**" **(Annexure-XXIV)** **<u>Resolution Passed:</u>** Approved.
36.26	To record the Bar Council of India letter No. BCI: D1453/2022: LE: BCI dated 03-10-2022, reported by Prof Rajesh Malik, Dean School of Law regarding regularisation of Second Section of three year LL.B course for the year 2020-21. **(Annexure-XXV)** **<u>Resolution Passed:</u>** Noted.
	The meeting ended with a vote of thanks to the Chair.

VICE-CHANCELLOR
(Chairperson)

REGISTRAR
(Secretary)

ACTION TAKEN REPORT

35th meeting of the Academic Council held on 15/09/2022

Item No.	Resolution Passed	Action Taken
35.1	**Confirmation of the Minutes of the 34th meeting of the Academic Council held on 19.05.2022.** **Resolution Passed:** The Minutes of the 34th meeting of the Academic Council held on 19.05.2022, were confirmed with following typographical amendments as suggested by the Council members: **a. R.No.-3:** In clause-3.1 relating to procedure for admission, the word "**GPET**" be corrected as "**GPAT**". **b. R.No.-4:** ➢ In the Annexure-III of Resolution No-4, in clause-2.4 the word "**GPET**" be corrected as "**GPAT**". ➢ In Clause-3.1, "a weightage of 50% to the Academic Qualification" be amended as "**a weightage of 70% to the Academic Qualification"** and "50% to the performance in the Interview" be amended as "**30% to the performance in the Interview**". ➢ In the end Note the phrase '**of the Vice-Chancellor**' be inserted between 'decision' and 'shall' and the sentence be read as : "…….the decision **of the Vice-Chancellor** shall be reported to the Academic Council in its next meeting for ratification." The minutes be accordingly amended by the concerned branch and to be kept in record. **Note:** Prof. Rajesh Kumar Malik and Dr. Bijender Singh gave their dissent regarding delayed circulation and item no.12 of the minutes of the 34th meeting, which are recorded at **Annexure-I**. **(Minutes already circulated)**	Academic & Council Branch has been directed for necessary corrections.
35.2	**To report, record and confirm the action taken on the resolutions of the 34th meeting of the Academic Council held on 19.05.2022.** **(Annexure-II)** **Resolution Passed:** The action taken on the resolutions of the 34th meeting of the Academic Council held on 19.05.2022, were reported, recorded and confirmed with the observation that the action taken should be made more specific. In case of the Action Taken Report on the Item No-23 & 24, it was resolved to constitute a Committee including Dean of the faculty. The approved syllabus will be sent to the Department for implementation.	Academic & Council has been directed to notify the Committee of the following persons: Prof. Dinesh Kumar Gupta, Prof. Sarika Sharma, Prof. Dinesh & Prof.

<table>
<tr><td></td><td></td><td>Rajesh Kumar Malik.</td></tr>
<tr><td colspan="3"><u>ITEMS FOR CONSIDERATION</u></td></tr>
<tr><td>35.3</td><td>To consider the following amendments to Ordinance-XI relating to Constitution of the Board of Studies and terms of office of its members:
<table>
<tr><th>Existing Clause</th><th>Proposed Amendments</th></tr>
<tr><td>1) Each Department shall have a Board of Studies with the following constitution:
a. Head of the Department, who shall be the Chairman and Convenor
b. All the Professors of the Department/Centre (ex-officio members)
c. One Associate Professor of the Department by rotation in order of seniority
d. One Assistant Professor of the Department by rotation in order of seniority
e. One or Two subject experts, not in the service of the University, to be nominated by the Vice Chancellor.
f. Does not exist.</td><td>1) Each Department shall have a Board of Studies with the following constitution:
a. Head of the Department, who shall be the Chairman and Convenor
b. All the Professors of the Department/Centre (ex-officio members)
c. One Associate Professor of the Department by rotation in order of seniority
d. One Assistant Professor of the Department by rotation in order of seniority
e. One or Two subject experts, not in the service of the University, to be nominated by the Vice Chancellor.
f. One or two industry experts or professionals to be nominated by the Vice-Chancellor.</td></tr>
</table>
<u>Resolution Passed</u>:
Resolved that the amendments to Ordinance-XI, relating to Constitution of the Board of Studies and terms of office of its members, be approved with the following minor corrections and recommended to the Executive Council for consideration:
f. One or two industry experts or professionals to be nominated by the Vice-Chancellor, out of a panel recommended by the Head of the Department. However, the Vice-Chancellor may also nominate any industry experts or professionals from outside the panel.</td><td>The recommendations regarding amendments to Ordinance-XI will be placed in the next meeting of the Executive Council.</td></tr>
<tr><td>35.4</td><td>To consider the recommendations of the Board of Studies of the Department of Computer Science & Information Technology dated 31-03-2022 and School Board of School of Basic Sciences dated 14-05-2022, for the scheme and syllabi of MCA (2 Year Programme), as per the CBCS, NEP-2020 and</td><td>Academic & Council has been directed to send the resolution to</td></tr>
</table>

	Learning Outcome Based Curriculum Framework (LOCF) guidelines, w.e.f. the Academic Session-2022-23. **(Annexure-II)** **<u>Resolution Passed</u>:** Resolved that the recommendation of the Board of Studies/School Board be approved.	the concerned Department of implementation.
35.5	To consider the recommendations of the Board of Studies of the Department of Computer Science & Information Technology dated 03-05-2022 and School Board of School of Basic Sciences dated 14-05-2022, for the scheme and syllabi of the course work for the Ph.D. programme in the Department of Computer Science and Information Technology, w.e.f. the Academic Session-2022-23. **(Annexure-III)** **<u>Resolution Passed</u>:** Resolved that the recommendation of the Board of Studies/School Board be approved.	Academic & Council has been directed to send the resolution to the concerned Department of implementation
35.6	To consider the evaluation report(s) received from the External and Internal Examiner of the thesis submitted by Late. Ms. Ekta (Roll No. 10087), a research scholar in the School of Education. **(Confidential Report, to be placed on table)** **Note:** 1. A proposal regarding award of Ph.D. degree posthumously to Late. Ms. Ekta (Roll No. 10087), a research scholar in the School of Education was submitted to the Academic Council for consideration in its 33rd meeting held on 12-10-2021. 2. The council resolved that Examination Branch may send thesis submitted by late. Ms. Ekta for evaluation. After receipt of the evaluation report, the matter may be submitted for consideration of the Academic Council. **<u>Resolution Passed</u>:** The Hon'ble Vice-Chancellor read out the Evaluation report of both the External Examiners and on the basis of the reports, the Council resolved to award Ph.D. Degree, posthumously, to Late. Ms. Ekta (Roll No. 10087), a research scholar in the School of Education and it be considered as a special case.	Academic & Council has been directed to send the resolution to the concerned Department of implementation
35.7	To consider the modalities for admission in Ph.D. programme under PwD quota as recommended by the Committee constituted vide notification No. CUH/2022/A&C/03 dated 05-01-2022. **(Annexure-IV)** **Note:** *The Academic Council vide its Resolution No-45 of the 33rd meeting held on 12-10-2021 resolved to constitute a Committee to devise modalities for admissions in Ph.D. programme under PwD quota, in consonance with the observation/ recommendations given by the Chief Commissioner for Persons with Disabilities.*	Academic & Council has been directed to issue a notification in this regard for implementation.

	Resolution Passed: Approved.	
35.8	To consider the recommendations of the Committee constituted vide Notification No. CUH/VCS/2022/Notification/98 dated 25-01-2022, regarding "*Proposal for setting up of Open and Distance Learning Centre at Central University of Haryana*". **(Annexure-V)** **Resolution Passed:** Approved in principal and recommended to the Executive Council for consideration. The courses will be started only after the approval of University Grants Commission, Distance Education Bureau.	The proposal will be placed in the next meeting of the Executive Council.
35.9	To consider the adoption of the University Grants Commission (Academic Collaboration between Indian and Foreign Higher Educational Institutions to offer Twinning, Joint Degree and Dual Degree Programmes) Regulations, 2022. **(Annexure-VI)** **Resolution Passed:** The Regulations has already been adopted in the 34th meeting of the Academic Council vide Resolution No.-22, hence withdrawn.	No action needed.
35.10	To consider the adoption of the University Grants Commission (Establishment and Operation of Academic Bank Of Credits in Higher Education) Regulations, 2021. **(Annexure-VII)** **Resolution Passed:** Resolved that the Regulations be adopted and an action plan be prepared for implementation.	Changes in Ordinances are required to be done for implementation of the same and a Committee needs to be constituted. Therefore, Academic & Council Branch has been directed to do the needful in this regard.
35.11	To consider the adoption of the University Grants Commission "Guidelines for Pursuing Two Academic Programmes Simultaneously". **(Annexure-VIII)** **Resolution Passed:** Resolved that the Guidelines be adopted and an action plan be prepared for implementation including necessary amendments in the related Ordinances of the University affected by its implementation.	
35.12	To discuss the matter related to moderation of Question Papers by external experts. Currently, as per **Ordinance XV: Programmes Leading to the Award of Postgraduate Degrees/Diplomas,** of the Ordinances of the University, moderation of question papers is required by a Board of Moderators. When this Ordinance was framed the University was merely having 1-2 Professors and there was no senior faculty member in most of the Department, whereas at present, the University has more than 25 Professors and 25 Associate Professors which enables the University to carry out in house moderation of question papers. **(Annexure-IX)** **Resolution Passed:** Resolved that the following amendments may be incorporated in the **Ordinance-XV** relating to "Programmes Leading To The Award Of	The recommendations regarding amendments to Ordinance-XV & Ordinance-XXIX will be placed in the next meeting of the Executive Council.

Postgraduate Degrees/Diplomas" and recommended to the Executive Council for consideration:

Existing Clause	Proposed Clause
10.4. Setting of question papers and Evaluation: The question papers for the End-Semester theory examination shall be set and evaluation of answer books shall be done by the examiners (Internal and/or External ordinarily in the ratio of 60:40) out of the Panel of Examiners recommended by the Board of Studies of the Department concerned on the basis of their expertise/ specialization. In case of unavailability of external examiners, the Vice Chancellor may allow the evaluation to be performed by the internal examiners only so that the declaration of results is not delayed. The question papers shall be moderated by a Board of Moderators to be appointed by the Controller of Examinations out of the panel drawn by Head/Incharge of the concerned department	**10.4. Setting of question papers and Evaluation:** The question papers for the End-Semester theory examination shall be set and evaluation of answer books shall be done by the examiners (Internal and/or External ordinarily in the ratio of 60:40) out of the Panel of Examiners recommended by the Board of Studies of the Department concerned on the basis of their expertise/ specialization. **In case of External Examiner, the question paper setting may be given to Professor/ Associate Professor or Assistant Professor with minimum five years of regular teaching experience at relevant level i.e. UG/PG.** Provided that in case of unavailability of external examiners, the Vice Chancellor may allow the **question paper setting** and evaluation to be performed by the Internal examiners only so that the conduct of examination and declaration of results is not delayed. The question papers shall be moderated by a Board of Moderators, consisting of the Head of the Department, one or two Professors/ Associate Professors/ External Experts to be appointed by the Controller of Examinations out of the panel drawn by Head/Incharge of the concerned department The question papers shall be moderated by a Board of Moderators (Internal and/or External) to be appointed by the Controller of Examinations out of the panel drawn by Head/Incharge of the concerned department. **The Assistant**

	Professor, having five years of teaching experience, may also be included in the panel.

Resolved that the following amendments may be incorporated in the **Ordinance-XXIX** relating to “Programmes Leading to the Award of Bachelor of Technology (B. Tech.) Degree” and recommended to the Executive Council for consideration:

Existing Clause	Proposed Clause
10.4.2. (ii) Moderation of Question Papers: The question papers shall be moderated by a Board of Moderators to be appointed by the Controller of Examinations out of the panel drawn by Head/In-charge of the concerned department.	**10.4.2. (ii) Moderation of Question Papers:** The question papers shall be moderated by a Board of Moderators to be appointed by the Controller of Examinations out of the panel drawn by Head/In-charge of the concerned department. **The Assistant Professor, having five years of teaching experience, may also be included in the panel of moderators.**

35.13 To discuss the Ordinance-XV-A (General Rules for Examinations) of the Ordinances of the University, regarding provisions for Striking off the name of grossly irregular Students. **(Annexure-X)**

<u>**Resolution Passed**</u>:

Resolved that the following amendments may be incorporated in the **Ordinance-XV-A**, relating to General Rules for Examination, be approved and recommended to the Executive Council for consideration:

Existing Clause	Proposed Clause
17. Attendance : (viii) No person shall be deemed to have satisfied the required conditions in respect of his instructions, unless in addition to the requirements regarding attendance and other conditions, he has appeared and satisfied by his performance the Head of the Department in such tests, written and/or oral, as may be held by him in his discretion. The Head of the Department shall have, and shall be deemed always to have had, the power to detain a student in the	**17. Attendance :** (viii) No person shall be deemed to have satisfied the required conditions in respect of his instructions, unless in addition to the requirements regarding attendance and other conditions, he has appeared and satisfied by his performance the Head of the Department in such tests, written and/or oral, as may be held by him in his discretion. The Head of the Department shall have, and shall be deemed always to have had, the power to detain a student in the

The recommendations regarding amendments to Ordinance-XV-A will be placed in the next meeting of the Executive Council.

	same class in which he has been studying, or not to send him/her in the same class in which he has been studying, or not to send him/her for the University Examination, in case he did not appear at the tests aforesaid or his performance was not satisfactory. The Head of the Department shall have power to strike off the name of a student who is grossly irregular in attendance in spite of warning, or when the absence of the student is for such a long period that he cannot put in requisite percentage of attendance.	same class in which he has been studying, or not to send him/her in the same class in which he has been studying, or not to send him/her for the University Examination, in case he did not appear at the tests aforesaid or his performance was not satisfactory. **Provided that the Head of the Department shall struck off the name of a student from roll who is absent continuously without permission for 10 or more working days.** **The student can be re-admitted with the approval of the Vice-Chancellor on the recommendation of the Head of the Department/ Staff Council on payment of Rs. 1000/- if re-admission is sought within 07 days after struck-off the name. The re-admission fee increases by Rs. 100/- per day thereafter.** **Every Department is required to display the attendance of enrolled students at the end of every month on the Notice Board of the concerned Department. In case of unreasonable absence, the parents/guardian of the students shall be intimated by the Head of the Department/Teacher nominated by the Head of the Department.**	
35.14	To discuss and resolve the matter related to excess intake (93 against 60 sanctioned seats vide BCI letter no. BCI:D:30:2021 (LE/Std. 9th Jan. 2021) dated 22-01-2021) in LL.B. 3-Year Programme during the Academic Session-2020-21, by the Department of Law. (**Annexure-XI)** **<u>Resolution Passed</u>:** When the Item was taken up for discussion, Dean, School of Law submitted a letter No. BCI:1265:2022(LE) dated 12-09-2022, received from Bar Council of India, regarding regularisation of excess admissions made during session-2020-21. BCI has intimated that the issue of regularisation of excess		Academic & Council Branch to follow with BCI & Head, Department of Law.

	admission during session-2020-21 shall be put before the Standing Committee of the Bar Council of India in its meeting proposed to be held in the month of September and the decision shall be forwarded to the University. Therefore it was resolved to deliberate on the issue, if required, after the outcome of the meeting of the Standing Committee of the BCI in this regard and **hence item is withdrawn.**	
35.15	To consider the draft "Open Access Policy of Central University of Haryana", as recommended by the NIRF (Overall) Committee. (**Annexure-XII)** **<u>Resolution Passed</u>:** Resolved that the Regulations be adopted and an action plan be prepared for implementation.	Academic & Council has been directed to send the resolution to the concerned Department of implementation
REPORTING ITEMS		
35.16	To report and record the action taken by the Vice-Chancellor in approving the starting of Ph.D. programmes in the Department of Journalism and Mass Communication w.e.f. Academic Session-2022-23. **Note:** The Academic Council vide Resolution No-17 of the 19th meeting held on 06-02-2016, authorised the Vice-Chancellor in approving the starting of Ph.D. programmes. **<u>Resolution Passed</u>:** The action taken by the Vice-Chancellor in approving the starting of Ph.D. programmes in the Department of Journalism and Mass Communication w.e.f. Academic Session-2022-23, was reported and recorded.	Reporting Item, no action needed.
35.17	To report and record the approval of the Pharmacy Council of India in starting M.Pharm (Pharmacognosy) programme from the Academic Session 2022-23 with an annual intake capacity of 06 students. **(Annexure-XIII)** **<u>Resolution Passed</u>:** The receipt of the approval of the Pharmacy Council of India in starting M.Pharm (Pharmacognosy) programme from the Academic Session 2022-23 with an annual intake capacity of 06 students, was reported and recorded.	Reporting Item, no action needed.
35.18	To report and record the action taken by the Vice-Chancellor in approving the request of the Head, Department of Physical Education and Sports regarding consideration of GEC-Fundamentals of Yoga, Course Code-SIAS YOGA 1101 GEC 3104 as the Credit requirements from the other departments, for the students of MPES 2020-22 batch. **Note:** During the COVID-19 pandemic, the students of Master of Physical Education and Sports (M.P.E.S.) 2020-22 batch have opted for Yoga as a Generic Elective Course in the 2nd Semester and 3rd semester. While filling out the examination forms for the 2nd semester, the students were not present in the physical mode due to COVID-19 pandemic restrictions and due to the	Reporting Item, no action needed.

	communication gap between the students and the department, the same could not be filled on the Registration portal. The students were promoted to the 3rd semester by calculating the average marks of the 1st semester and internal marks of 2nd semester. The students have attended the classes for YOGA GEC-Fundamentals of Yoga, Course Code-SIAS YOGA 1101 GEC 3104 and submitted work assignments. The internal marks for the same have been forwarded to the Examination Branch by the concerned TIC of the Department of Yoga. **Resolution Passed:** The action taken by the Vice-Chancellor in approving the request of the Head, Department of Physical Education and Sports regarding consideration of GEC-Fundamentals of Yoga, Course Code-SIAS YOGA 1101 GEC 3104 as the Credit requirements from the other departments, for the students of MPES 2020-22 batch, was reported and recorded.	
	Supplementary Items	
35.19	To consider the recommendations of the Board of Studies of the Department of Computer Science and Information Technology dated 31-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of M.Sc. (Data Science) programme (1st Semester), w.e.f. the Academic Session-2022-23. **Annexure-XIV** **Resolution Passed:** Resolved that the recommendations of the Board of Studies of the Department of Computer Science and Information Technology dated 31-08-2022 and School Board of School of Basic Sciences dated 12-09-2022, for the scheme and syllabi of M.Sc. (Data Science) programme (1st Semester), w.e.f. the Academic Session-2022-23, be approved.	Academic & Council has been directed to send the resolution to the concerned Department of implementation
35.20	To consider the application of Mr. Manish Kumar (Roll No. 191217), Research Scholar, Department of Mathematics, on the recommendations of the DRC/BoS & School Board, regarding waiving off the remaining residential period of the Ph.D. programmes. **(Annexure-XV)** **Note:** *Mr. Manish Kumar has been selected as Assistant Professor in Chhattisgarh State Government and also submitted his resignation from SRF-UGC.* **Resolution Passed:** Resolved that the recommendation of the Board of Studies/ School Board regarding completion of the remaining period of the residency in respect of Mr. Manish Kumar (Roll No. 191217), Research Scholar, Department of Mathematics, be approved. The Council further resolved that the scholar shall complete the remaining residency period, in one span, by taking leave from his employer, in stipulated time.	Academic & Council has been directed to send the resolution to the concerned Department of implementation

35.21	To consider the recommendations of the Board of Studies of the Department of Geography dated 11-05-2022 and School Board of School of Basic Sciences dated 12.09.2022, for the case of Mr. Sourabh Yadav (Roll No. 200785) to complete the period of two years regular for his Ph.D. program as per relevant university ordinance.**(Annexure-XVI)** Note: *Mr. Sourabh Yadav (Roll No. 200785) has been selected as Lecturer Inter College, Jasrana, Firozabad (Uttar Pradesh Secondary Education Service Selection Board).* **Resolution Passed:** Resolved that the recommendation of the Board of Studies/ School Board regarding completion of the remaining period of the residency with respect of Mr. Sourabh Yadav (Roll No. 200785), Research Scholar, Department of Geography, be approved. The Council further resolved that the scholar shall complete the remaining residency period, in one span, by taking leave from his employer, in stipulated time.	Academic & Council has been directed to send the resolution to the concerned Department of implementation
	The meeting ended with remarks that the meetings of the Academic Council will be conducted as per the approved regulation for conduct of the meetings of the Academic Council, with next meeting scheduled on 07-10-2022.	

Central University of Haryana
Department of Mathematics

Minutes of BOS Meeting held on 10.05.2022

A meeting of the Board of Studies (BOS) of the Department of Mathematics, School of Basic Sciences, Central University of Haryana, Mahendergarh was held on 10.05.2022 from 02:30 PM to 04:30PM in hybrid mode (link of the meeting: https://meet.google.com/qcn-cftp-nov).

The following members were present:

1. Prof. Kapil Kumar Sharma, (Department of Mathematics, South Asian University, New Delhi) External Expert (online)
2. Prof. Dinesh Khurana, (Department of Mathematics, Panjab University, Chandigarh) External Expert (online)
3. Prof. Rajesh Kumar Gupta (Department of Mathematics, CUH) Chairperson
4. Prof. Anil Kumar Yadav (Department of Mathematics, CUH) Invitee
5. Dr. Arun Kajla (Department of Mathematics, CUH) Member
6. Dr. Jagjeet (Department of Mathematics, CUH) Invitee

Following agenda items were considered and resolved accordingly:

1. Approval for Syllabi of 5-year integrated B.Sc.-M.Sc. Mathematics (III, IV, V and VI Semester) for 2021-22 batch.
2. Approval for Syllabi of 5-year integrated B.Sc.-M.Sc. Mathematics (I to VI Semester) for 2022-23 batch.
3. Any other matter with the permission of Chair: Panel of Paper-setters and Examiners for the End term examinations (Dec. 2022) and (June 2023) of M.Sc. (Mathematics) and integrated B.Sc.-M.Sc. (Mathematics)

1. Approval of Syllabi of 5-year integrated B.Sc.-M.Sc. Mathematics (III, IV, V and VI Semester) for 2021-22 batch

The BOS considered and recommended the Syllabi (III, IV, V and VI Semester) of the courses of 5-year integrated B.Sc.-M.Sc. Mathematics for 2021-22 batch as per UGC Curriculum Framework 2019 and NEP 2020 with some modification. All the suggestions are incorporated in the syllabi.

2. Approval of Syllabi of 5-year integrated B.Sc.-M.Sc. Mathematics (I to VI Semester) for 2022-23 batch

The BOS considered and recommended the Syllabi (I to VI Semesters) of the courses of 5-year integrated B.Sc.-M.Sc. Mathematics for 2022-23 batch as per UGC Curriculum Framework 2019 and NEP 2020 with some modifications. New generic elective courses (GEC) are introduced as per suggestions of external experts. Also, the typographical and grammatical mistakes and typesetting errors were removed. Suggested books are also included in the syllabi.

3. Any other matter with the permission of Chair: Panel of Paper-Setters and Examiners for Dec. 2022 and June 2023

The Board approved the Panels of Paper-Setters/Examiners for M.Sc. Mathematics and integrated B.Sc.-M.Sc. Mathematics for both the Semesters of academic year 2022-23 for all regular and reappear students.

The approved panels are being sent to COE under sealed cover. Further, Head, Dept. of Mathematics is authorized to supply additional names, if required.

email consent attached for Rajesh

Prof. Kapil Kumar Sharma

email consent attached for Rajesh

Prof. Dinesh Khurana

Prof. Anil Kumar Yadav

Prof. Rajesh Kumar Gupta

Dr.Arun Kajla

Dr. Jagjeet

Minutes of Board of Studies (BOS)

4 messages

Mathematics Department <hodmaths@cuh.ac.in> Thu, May 12, 2022 at 10:57 PM
To: arun kajla <arunkajla@cuh.ac.in>, akyadav@cuh.ac.in, Kapil Sharma <kapil.sharma@sau.ac.in>, dkhurana <dkhurana@pu.ac.in>, "Dr. Rajesh Kumar Gupta" <rajeshgupta@cuh.ac.in>

Dear Sir,
Please find the attached minutes of the meeting of the Board of Studies (BOS) of the Department of Mathematics, CUH held on 10.05.2022 in online mode (link of the meeting: https://meet.google.com/qcn-cftp-nov at 2.30 PM.

All relevant documents are also attached.

Kindly approved the attached minutes of the meeting via reply email.

....
Thanks and Regards

डॉ. राजेश कुमार गुप्ता / Dr. Rajesh Kumar Gupta
प्रोफेसर / Professor
गणित विभाग / Department of Mathematics
हरियाणा केन्द्रीय विश्वविद्यालय / Central University of Haryana
जंत-पाली / Jant-Pali, महेंद्रगढ़ / Mahendergarh -123031
हरियाणा / Haryana, भारत INDIA

11 attachments

Annexure I MT.pdf
2073K

Annexure II MT.pdf
2032K

BOS Minutes (10.05.2022).docx
16K

Annexure-III_ Examiners List (Integrated B.Sc.-M.Sc. Mathematics Semester-I).pdf
120K

Annexure-III_ Examiners List (Integrated B.Sc.-M.Sc. Mathematics Semester-III).pdf
39K

Annexure-III_ Examiners List (Integrated B.Sc.-M.Sc. Mathematics Semester-II).pdf
31K

Annexure-III_ Examiners List (Integrated B.Sc.-M.Sc. Mathematics Semester-IV).pdf
39K

Annexure-III_ Examiners List (M.Sc. Mathematics Semester-I).pdf
51K

Annexure-III_ Examiners List (M.Sc. Mathematics Semester-II).pdf
247K

Annexure-III_ Examiners List (M.Sc. Mathematics Semester-III).pdf
152K

Annexure-III_ Examiners List (M.Sc. Mathematics Semester-IV).pdf
172K

dkhurana <dkhurana@pu.ac.in> Fri, May 13, 2022 at 10:27 AM
To: Mathematics Department <hodmaths@cuh.ac.in>
Cc: arun kajla <arunkajla@cuh.ac.in>, akyadav@cuh.ac.in, Kapil Sharma <kapil.sharma@sau.ac.in>, "Dr. Rajesh Kumar Gupta" <rajeshgupta@cuh.ac.in>

Approved.

Best wishes,

Dinesh Khurana

[Quoted text hidden]

Kapil Sharma <kapil.sharma@sau.ac.in> Fri, May 13, 2022 at 10:30 AM
To: dkhurana <dkhurana@pu.ac.in>
Cc: Mathematics Department <hodmaths@cuh.ac.in>, arun kajla <arunkajla@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Rajesh Kumar Gupta" <rajeshgupta@cuh.ac.in>

Approved.
Best regards
kapil
[Quoted text hidden]
--
Kapil K Sharma
Professor
Department of Mathematics
South Asian University
Akbar Bhavan, Chanakyapuri
New Delhi, India
kapil.sharma@sau.ac.in
9855682505
Website: www.sau.ac.in

Prof A. K. Yadav <akyadav@cuh.ac.in> Fri, May 13, 2022 at 12:11 PM
To: Mathematics Department <hodmaths@cuh.ac.in>
Cc: arun kajla <arunkajla@cuh.ac.in>, Kapil Sharma <kapil.sharma@sau.ac.in>, dkhurana <dkhurana@pu.ac.in>, "Dr. Rajesh Kumar Gupta" <rajeshgupta@cuh.ac.in>

Approved as attached with minor edits.

Regards,
AKY
[Quoted text hidden]

5 attachments

BOS Minutes (10.05.2022).docx
16K

2022-23Final SyllabiSchemeIntegratedBSc-MSc.doc
1341K

2021-22Final SyllabiScheme IntegratedBSc-MSc.doc
1274K

2021-22Final SyllabiScheme IntegratedBSc-MSc.pdf
2082K

Central University of Haryana

Department of Mathematics

Minutes of BOS Meeting held on 06.09.2022

A meeting of the Board of Studies (BOS) of the Department of Mathematics, School of Basic Sciences, Central University of Haryana, Mahendergarh was held on 06.09.2022 from 2:15 PM to 4:30 PM in online mode (link of the meeting: https://meet.google.com/bqa-jsxp-wgx).

The following members were present:

1. Prof. Kapil Kumar Sharma, (Dept. of Mathematics, South Asian University, New Delhi) External Expert
2. Prof. Dinesh Khurana, (Dept. of Mathematics, Panjab University, Chandigarh) External Expert
3. Prof. Rajesh Kumar Gupta, Dept. of Mathematics, CUH, Chairperson
4. Prof. A. K. Yadav, Dept. of Mathematics, CUH, Member
5. Dr. Jitender Kumar, Associate Professor, Dept. of Mathematics, CUH, Member
6. Dr. Arun Kajla, Dept. of Mathematics, CUH, Member
7. Dr. Jagjeet, Dept. of Mathematics, CUH, Special Invitee

Following agenda items were considered and resolved accordingly:

1. Inclusion of MOOC courses (SWAYAM) in the Syllabi of 5-year integrated BSc-MSc Mathematics (III, IV, V, and VI Semesters) for the **2021-22 batch,** and (I to VI Semesters) for the **2022-23 batch.**
2. Any other matter with the permission of the Chair.

Agenda Item 1:

*Inclusion of MOOC courses (SWAYAM) in the Syllabi of 5-year integrated BSc-MSc Mathematics (III, IV, V, and VI Semesters) for the **2021-22 batch,** and (I to VI Semesters) for the **2022-23 batch***

Courses of 5-year integrated BSc-MSc Mathematics having similarity more than 50% with corresponding MOOC courses have been identified, perused and discussed. These are recommended to be included for offering as equivalent courses:

Rajesh 06/09/22

List of Courses in Integrated BSc-MSc, and MSc Mathematics programs:

Sr.	CUH Program/Semester	CUH Course Title/Type(credits)	MOOC Course	Similarity
1	BSc-MSc (Integ.)/ 1ST	Calculus /Core (6)	Calculus of One Real Variable	75-80%
2	BSc-MSc (Integ.)/ 2ND	Multivariate Calculus /Core (6)	Calculus of Several Real Variables	75-80%
3	BSc-MSc (Integ.)/ 2ND	Ordinary Differential Equations/Core (6)	Differential Equations	70%
4	BSc-MSc (Integ.)/ 3RD	Group Theory /Core (6)	Introduction to Abstract Group Theory	85%
5	BSc-MSc (Integ.)/ 3RD	Probability Theory and Statistics /Core (6)	Introduction to Probability Theory and Statistics	80%
6	BSc-MSc (Integ.)/ 3RD	Real Analysis/Core (6)	Real Analysis	90%
7	BSc-MSc (Integ.)/ 4TH, 5TH	Advanced Algebra /Core (6) Linear Algebra /Core (6)	Introduction to Abstract and Linear Algebra	60% 50%
8	BSc-MSc (Integ.)/ 4TH	Partial Differential Equations and Calculus of Variation /Core (6)	Partial Differential Equations	65%
9	BSc-MSc (Integ.)/ 5TH, MSc 1ST	Linear Algebra /Core (6, 4)	Linear Algebra	75-80%
10	BSc-M.Sc (Integ.)/ 6TH	Numerical Methods /Core (6)	Numerical Methods	75-80%
11	BSc-MSc (Integ.)/ 6TH MSc/1ST	Complex Analysis/Core (6, 4)	Complex Analysis	80%
12	MSc/ 1ST, 4TH	Algebra-I /Core (4) Algebra-II /Core (4)	Rings and Modules	50% 50%
13	MSc /3 RD	Operations Research /DSEC (4)	Operations Research	90%
14	MSc /4TH	Measure Theory and Integration /DSEC (4)	Measure Theory	90%

DSEC/DCEC: Discipline Specific/Centric Elective Course

GEC: Generic Elective Courses

AECC: Ability Enhancement Compulsory Courses

SEC: Skill Enhancement Courses

The BOS has recommended that the MOOC courses (SWAYAM) having similarity more than 75% with the core courses may be offered to the students. For SEC/GEC/AECC/DCEC/DSEC courses, the students may opt from the MOOC courses provided these courses are not in the list of core courses and student have not studied similar courses earlier. Since, the list of MOOC courses (SWAYAM) keeps changing, BOS authorizes the departmental committee to finalize the list of MOOC courses for each semester based on the above criteria.

Agenda Item 2:

Any other matter with the permission of the chair. ***NIL***

The meeting ended with thanks to the Chairperson and members of BOS.

for (online consent)

Prof. Kapil Kumar Sharma

06/09/22

Prof. Rajesh Kumar Gupta

Dr. Jitender Kumar

for (online consent)

Prof. Dinesh Khurana

Prof. A. K. Yadav

Arun Kajla

Dr. Arun Kajla

Dean School Of Basic Sciences <deansobs@cuh.ac.in>

School Board Meeting on 12-09-2022 at 10:30 A.M. onwards

Dean School Of Basic Sciences <deansobs@cuh.ac.in> Wed, Sep 14, 2022 at 12:34 PM
To: "आचार्य पवन कुमार शर्मा Prof. Pawan K. Sharma" <talk2pawan@gmail.com>
Cc: bonnie_kahlon@yahoo.com, ckjaggi@gmail.com, sukhdeepsingh.cse@dcrustm.org, amitach1@yahoo.com, Amita Chandra <achandra@physics.du.ac.in>, HoD Maths <hodmaths@cuh.ac.in>, HOD Physics <hodphysics@cuh.ac.in>, HOD Statistics <hodstatistics@cuh.ac.in>, CS and IT <hodcomputerscience@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>, "HoD, Chemistry" <hodchemistry@cuh.ac.in>, ssunita@cuh.ac.in, "Dr. Suneel Kumar" <suneelkumar@cuh.ac.in>, "Dr. Harish Kumar" <harishkumar@cuh.ac.in>, Rajeshgupta@cuh.ac.in, "Dr. Manoj Gupta" <mkgupta@cuh.ac.in>, keshav@cuh.ac.in, Suraj Arya <surajarya@cuh.ac.in>, jitendra@cuh.ac.in, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, arunkajla@cuh.ac.in, "Dr. Rakesh Kumar" <rks@cuh.ac.in>, "Dr. Kapil Kumar" <kapilstats@cuh.ac.in>, kahlon_s@pu.ac.in, "Dr. Vinod Kumar" <vinodkumar@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Devendra Kumar" <devendrastats@cuh.ac.in>, drjitendra@cuh.ac.in

Respected Madam/Sir,
Please find herewith the revised minutes (with minor modification in resolution for agenda no 3a and 3b) of the meeting of the School Board held on 12-09-2022 for your kind consideration and approval.
With Warm Regards

(Revised) Minutes of Meeting of the School Board of School of Basic Sciences held on 12.09.2022

A meeting of the **School Board of School of Basic Sciences**, Central University of Haryana, Mahendergarh was held on **12.09.2022** at **10:30 A.M.** onwards via offline and online (https://meet.google.com/rvh-ukja-fwm) mode in the office of the Dean, School of Basic Sciences, Central University of Haryana.

The following members were present in the meeting:

1. **Dr. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Dr. Keshav Singh Rawat** (Member)
   Head, Department of Computer Science and IT
   Central University of Haryana, Mahendergarh
3. **Dr. Jitendra Kumar** (Member)
   Head, Department of Geography
   Central University of Haryana, Mahendergarh
4. **Dr. Rajesh Kumar Gupta** (Member)
   Head, Department of Mathematics
   Central University of Haryana, Mahendergarh
5. **Dr. Suneel Kumar** (Member)
   Head, Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
6. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
7. **Prof. Sunita Shrivastava** (Member)
   Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
8. **Dr. Manoj Kumar Gupta** (Member)

Department of Chemistry
Central University of Haryana, Mahendergarh

9. **Dr. Suraj Arya** (Member)
Department of CS & IT
Central University of Haryana, Mahendergarh

10. **Dr. Manish Kumar** (Member)
Department of Geography
Central University of Haryana, Mahendergarh

11. **Dr. Arun Kajla** (Member)
Department of Mathematics
Central University of Haryana, Mahendergarh

12. **Prof. Pawan Kumar Sharma** (External Subject Expert)
Professor, Department of Chemistry
Kurukshetra University, Kurukshetra, Haryana

13. **Prof. Chandra K. Jaggi** (External Subject Expert)
Professor, Department of Operational Research
Faculty of Mathematical Sciences, DU, Delhi

14. **Prof. Sukhdeep Singh** (External Subject Expert)
Professor, Department of Computer Science & Engg.
DCRUST, Murthal, Sonipat

15. **Prof. Amita Chandra** (External Subject Expert)
Professor, Department of Physics & Astrophysics Joined online
North Campus, DU, Delhi

16. **Prof. Simrit Kahlon** (External Subject Expert)
Professor, Department of Geography
Panjab University, Chandigarh

17. **Prof. Anil Kumar Yadav** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

18. **Dr. Jitendra Kumar** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

19. **Dr. Devendra Kumar** (Special Invitee)
TIC, Department of Statistics
Central University of Haryana, Mahendergarh

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

Item No	**Description and Recommendation**	**Annexure**
1	Confirmation of the minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022.	
	The minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022 were confirmed.	**Annexure-1-SOBS**
2	To consider and approve the minutes of the meeting of the Board of	

	Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022, be approved.	**Annexure-A**
2a	To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-CH**
2b	To consider and approve the Scheme for first three years and Syllabi for second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in the BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc. programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020. **It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.** **Resolved that the Scheme for first three years (with minor modifications in first and second year) and Syllabi for the second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-II-CH**
2c	To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of	

	Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme and syllabi of the Integrated B.Sc.-M.Sc. programme have been designed. **Resolved that the Scheme and Syllabi for the first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-III-CH**
3.	To consider and approve the minutes of the meetings of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022, be approved.	**Annexure-B**
3a	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and suggested the improvement in the course title of Programming for Data Science as "Programming for Data Science using python" in the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023). **Further, the board suggested that the Department of Computer Science and Department of Statistics should sit together and should try to come up with a Collaborative model for the M.Sc. Data Science programme. In view of that the board resolved that the first semester Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, with minor changes as mentioned above be approved and recommended the same to the Academic Council for consideration and approval.**	**Annexure-I-CS**
3b	To consider and approve the Scheme and Syllabi of the Diploma in	

	Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and the board noted that the proposed one year Diploma Programme is of UG level and of 40 credits. However, the existing CUH ordinance allows the Diploma at PG level only with 52 credits(+-4). In view of that the board suggested that the Diploma in Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022, may be offered after the amendments in the university ordinance regarding guidelines of credits for the UG degree level diploma with updated syllabi.	**Annexure-II-CS**
4.	To consider and approve the minutes of the meeting of the Board of Studies of the Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022.	
	Resolved that the minutes of the meeting of Board of Studies of Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022, be approved	**Annexure-C**
4a	To consider and approve the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval after the incorporation of suggested corrections given below: **i) The name of the course "Solar Energy and Physics of Voltaic" is to be changed as "Fundamentals of Solar Energy".** **ii) In case of "Dissertation" offered to students in Semester IV, it should be explicitly mentioned that a continuous monitoring is required to be done. For that purpose, a minimum of two presentations are to be presented by students during the semester.** **iii) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of M.Sc. (Physics) 2021-23 batch.**	**Annexure-I-PH**
4b	To consider and approve the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session	

	2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Discussed in detail the Schemes and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme w.e.f. Academic Session 2022-2023 (Annexure-IIB-PH)and for 2021-26 batch (Annexure-IIA-PH). **Resolved that the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session 2022-2023) and for 2021-26 batch as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to implementation of below-mentioned changes:** **i) The number of practical lectures for DSE, mentioned in the schemes of Semester V and Semester VI should be four instead of two.** **ii) In case of "Dissertation" offered to students in Semester X, it should be explicitly mentioned that a continuous monitoring is required. For that purpose, a minimum of two presentations by each student are required during the semester.** **iii) A course related to "Soft Skills" may be added in the list of Ability Enhancement courses that can be offered by Department of Psychology, or Department of Education or Department of English Studies** **iv) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of Integrated B.Sc. M.Sc (Physics) for 2021-26 batch.**	**Annexure-IIA-PH** **Annexure-IIB-PH**
4c	To consider and approve the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to incorporation of below-mentioned changes: **i) The number of DCEC courses for the PhD (Physics) course work should be three. Therefore, it was decided unanimously to remove the course of "Nanotechnology and Ion Beam".**	**Annexure-III-PH**

5.	To consider and approve the minutes of the meeting of Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022	**Annexure-D1, D2, D3**
	Resolved that the minutes of the meeting of the Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022 be approved.	
5a	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-MT**
5b	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2022-27 (1-6 Semesters) as approved in BOS meeting of Department of Mathematics held 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	**Annexure-II-MT**
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics w.e.f Academic Session 2022-23, as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved, and recommended the same to Academic Council for consideration and approval.	
5c	Recommendation on the application dated 07-01-2022 received from Mr. Manish Kumar (Roll no. 191217), Research Scholar, on the recommendation of DRC (**Annexure–III-MT**), Department of Mathematics dated 13-01-2022 and BoS (16-03-2022, **Annexure-D1**).	**Annexure-III-MT**
	The case of Mr. Manish Kumar (Roll no. 191217), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 09-08-2019 and the topic of his research was approved on 19-11-2020 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Manish Kumar (Roll no. 191217), Research Scholar is required to complete a minimum residency period of two years after his topic approval date as per clause no 7.10 and 9f of Ordinance-II(A) 2019 for Ph.D. It is further resolved that the remaining**	

	residency period of 10 months 13 days should be completed in one go by Mr. Manish Kumar as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.	
6.	To consider and approve the minutes of the meeting of the Board of Studies (BOS) of the Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of Department of Statistics, School of Basic Sciences held on 10-05-2022 be approved.	**Annexure-E**
6a	To get approval for changing the instructions/notes in the course for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that changing the instructions/notes in the courses for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022, be approved and recommended the same to the Academic Council for consideration and approval.	**Annexure-E**
6b	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics, held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The agenda item 6b is withdrawn as the similar programme i.e. M.Sc. Data Science has been offered by the Department of Computer Science & Information Technology under the same School. **After detailed discussion, the board suggested that the Department of Statistics and Department of Computer Science & Information Technology may start some collaborative and common programmes in near future as per the availability of the faculty members and resources.**	**Annexure-I-ST**
6c	To consider and approve the Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the revised and updated Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics	**Annexure-II-ST**

	held on 10-05-2022, be approved and recommended the same to Academic Council for consideration and approval.	
7.	To consider and approve the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3).	
	Resolved that the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3) be approved.	**Annexure-F1, F2, F3**
7a	To consider and approve the syllabus of M.Sc. Geoinformatics programme in the Department of Geography.	
	Resolved that Scheme and Syllabi of M.Sc. Geoinformatics, two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Geography held on 24-08-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-Geog**
7b	To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job as recommended by Departmental Research Committee (DRC) held on 20-04-2022 and Board of Studies (BoS) meeting held on 11-05-2022 and to recommend the case for Academic Council.	
	The case of Mr. Sourabh Yadav (Roll no. 200785), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 29-11-2020 and the topic of his research was approved on 26-10-2021 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Sourabh Yadav (Roll no. 200785), Research Scholar is required to complete a minimum period of two years after his topic approval date as per clause no 9e and 9f of Ordinance-II(A) for Ph.D 2020. It is further resolved that the remaining period of 1 year 10 months 27 days should be completed in one go by Mr. Sourabh Yadav as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.**	**Annexure-II-Geog**
8.	Any other item(s) with the permission of the Chair.	
	No item was discussed	

The meeting ended with thanks to the Chair.

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(**NAAC Accredited 'A' Grade**)

Curriculum and Syllabi

Integrated B.Sc.-M.Sc. (Mathematics)

(Batch 2021-2026)

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	√
Approval Date :	04/09/2021	20/09/2021	12/10/2021
Approval Date :	10/05/2022	14/05/2022	
Approval Date :	06/09/2022	12/09/2022	07/10/2022

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VISION AND MISSION

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavor's and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

Vision and Mission of the Department

Vision

To be an internationally recognized centre for research and teaching in mathematics. To encourage excellence, innovation, integrity and values for society in the department. To produce global leaders for academic and industry by imparting multidisciplinary and contemporary mathematical knowledge to the students.

Mission

- To contribute towards building calibre of the students by providing quality education and research in Mathematics through updated curriculum, effective teaching learning process.

- To impart innovative skills, team-work, ethical practices to the students so as to meet societal expectations.
- To build a strong base in Mathematics for various academic programs across the institute.

1. Background

i) Preamble

Mathematics is a fundamental part of human thoughts and logic, and Integral to attempts at understanding the world and ourselves. Mathematics, as we all know, provide an effective way of building mental discipline and encourages logical reasoning. In addition, mathematical knowledge plays a vital role in understanding the contents of others subjects such as Basic Sciences, Social sciences and in Music and Art. This has been argued and established that there can't be a nation without mathematics. Today, more than ever before, the challenges of globalization and digitalization obligate mathematicians and researchers to go beyond the local, national, and even continental frontiers of their knowledge.

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms. At the outset, it may well be stated that NEP 2020 document owes it origin to meet the fundamental challenges of ever changing academics scales at Global level. Thus, a high priority task in the context of future education development agenda in India is fostering quality higher education. The idea is to involve young minds in knowledge production and of greater participation of knowledge itself. Participation in knowledge, by young minds, is an important departure from the existing structure at undergraduate level. Implementation of new structure is based on guiding principles of Learning Outcome based Curriculum Framework (LoCF). The fundamental premise underlying the learning outcome based approach to curriculum planning and development is that higher education qualifications such as Bachelor-Master integrated degree programme are awarded on the basis of demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of Graduate-Master of a programme of study. The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the Bachelor-Master integrated with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen student's experiences as they engage themselves in the programme of their choice. The Graduate-Master programme will prepare the students for academia and also prepare them to use this knowledge for employment. The given programme elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programme also state the attributes that it offers to inculcate at the graduation level. The Bachelor-Master integrated attributes encompass values related to wellbeing, emotional stability, critical thinking, and also skills for employability. The programme prepares students for sustainability and lifelong learning. This also tries to change the perception towards studying mathematics. This course is designed to break the stereotypes of mathematics learning and create interest amongst students to do Mathematics. This programme is organized to provide the greatest flexibility to its students. There are Core Disciplinary papers that provide the fundamental knowledge in the discipline of mathematics. The programme is otherwise envisaged to provide a large amount of choice so that students can adapt their education on the basis of their interests. These provide not just mathematical knowledge and skills but also a vital skill in other disciplines as well.

Flexible learning is important to choose one's academic pathway leading to the award of certificate, diploma, and degree. The multiple entry exit will be according to the UGC guidelines and University ordinances.

ii) Introduction:

The objective of this programme is to prepare the students with a new vision. One of the significant reforms in integrated B.Sc.-M.Sc. (Mathematics) programme is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, especially in mathematics. The learning outcomes will be attained by students through skills acquired during this programme of study. Programme learning outcomes will include subject-specific skills and generic skills, including transferable global skills and competencies. This programme would also focus on knowledge and skills that will prepare students for employment, and for further studies.

The quality education in mathematics is very challenging task for higher education system in India. In designing this course we have taken appropriate measures to define the minimum levels of learning for students in integrated B.Sc.-M.Sc. (Mathematics) programme. The given programme elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programme also state the attributes that it offers to inculcate at the different levels. It is designed to bring out the best intellect of the student and also allow the student to keep pace with the contemporary development.

The Integrated B.Sc.-M.Sc. (Mathematics) programme offers student's access to Core Courses, Ability Enhancement Compulsory Courses, Skill Enhancement Courses, Discipline Specific Electives and Generic Electives. The Programme-learning outcomes and course learning outcomes have been clearly specified to help prospective students, parents and employers understand the nature and extent of the degree programme; to maintain national and international standards, and to help in student mobility.

iii) Learning Outcomes Based Approach to Curriculum Planning:

The learning outcomes-based curriculum framework for Integrated B.Sc.-M.Sc. (Mathematics) programme is based on the expected learning outcomes and graduate-master attributes that a graduate-master in mathematics is expected to attain. The curriculum for Integrated B.Sc.-M.Sc. (Mathematics) programme is prepared keeping in mind the needs and aspirations of students in mathematics as well as the evolving nature of mathematics as a subject. The course learning outcomes and the programme learning outcomes specify the knowledge, understanding, skills, attitudes and values that a student completing this degree is expected to know. The qualification of Integrated B.Sc.-M.Sc. (Mathematics) programme is awarded to a student who can demonstrate the attainment of these outcomes.

iv) Nature and Extent of the Integrated B.Sc.-M.Sc. (Mathematics) Programme:

The Integrated B.Sc.-M.Sc. (Mathematics) is of five years duration. Each year is divided into two semesters. The total numbers of semester are ten and it is presumed that each semester will be of eighteen weeks duration. The teaching and learning in the Integrated B.Sc.-M.Sc. (Mathematics) will involve theory classes (lectures), practical classes and tutorial classes.

Mathematics is usually described as the abstract science of number, quantity and space along with their operations. The scope of Mathematics is very broad and it has a wide range of applications in natural sciences, engineering, economics, social sciences and in data science. Integrated B.Sc.-M.Sc. (Mathematics) programme aims at developing the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life. Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector and industry. The Integrated B.Sc.-M.Sc. (Mathematics) programme covers the full range of mathematics, from classical Calculus to Modern Cryptography, Information Theory, and Network Security. The course lays a structured foundation of Calculus, Real & Complex analysis, Abstract Algebra, Differential Equations (including Mathematical Modelling), Number Theory, Graph Theory, and C++ Programming exclusively for Mathematics. An exceptionally broad range of topics covering Pure & Applied Mathematics: Linear Algebra, Metric Spaces, Statistics, Linear Programming, Numerical Analysis, Mathematical Finance, Coding Theory, Mechanics and Biomathematics cater to varied interests and ambitions. Also hand on sessions in Computer Lab using various Computer Algebra Systems (CAS) softwares such as Maple, Mathematica, MATLAB, Maxima and R to have a deep conceptual understanding of the above tools are carried out to widen the horizon of students' self experience. The courses like Biomathematics, Mathematical Finance etc. emphasize on the relation of mathematics to other subjects like Biology, Economics and Finance. To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of Generic electives for example one can opt for economics as one of the GE papers. Skill enhancement Courses enable the student acquire the skill relevant to the main subject. Choices from Discipline Specific Electives provides the student with liberty of exploring his interests within the main subject. The key importance is the theme of integrating mathematical and professional skills. The well structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research.

2. Aims of Integrated B.Sc.-M.Sc. (Mathematics) programme:

The overall aims of Integrated B.Sc.-M.Sc. (Mathematics) programme are follows:

i) Inculcate strong interest in learning mathematics and have balanced knowledge for understanding of definitions, key concepts, principles and theorems in mathematics.

ii) Enable students to apply the knowledge and skills acquired by them during the programme to solve problems in mathematics.

iii) Train students to communicate mathematical ideas in a lucid and effective manner, which will be helpful in wage employment, self-employment and entrepreneurship.

iv) Provide students with sufficient knowledge and skills that enable them to undertake research in different fields of mathematics and related disciplines.

v) To encourage the use of relevant software such as MATLAB, Maple, R and MATHEMATICA.

3. Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

Program Outcomes:

Students enrolled in the integrated B.Sc.-M.Sc. Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.

PO-8	Leadership and Teamwork abilities	Ability to learn and work in a groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

Programme Specific Outcomes (PSOs):

On completion of Integrated B.Sc.-M.Sc. (Mathematics) Programme a student**:**

Number	**Programme Specific Outcomes**
PSO-1	Will have a strong foundation in both pure and applied mathematics.
PSO-2	Will be able to apply mathematical skills for solving problems and for preparing various competitive exams.
PSO-3	Will be able to communicate mathematical knowledge effectively, in writing as well as orally.
PSO-4	Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.
PSO-5	Will have basic knowledge of programming and computational techniques as required for employment.
PSO-6	Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.

PSO-7	Will be able to locate and analyse the different mathematical texts with appropriate theoretical framework.
PSO-8	Have the knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in science, social science, engineering and technology.
PSO-9	Should be able to develop analytical skills, critical thinking, creativity, communication and presentation skills through assignments, seminar and project work.
PSO-10	Should be able to apply their skills and knowledge that translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

4. Integrated B.Sc.-M.Sc. (Mathematics) Attributes:

On completion of the course students are expected to have acquired the skills of multi dimensional thinking, analytical reasoning, rational enquiry, problems solving, effective communication, and exploring the different areas of pure and Applied mathematics. The attributes expected from the students of Integrated B.Sc.-M.Sc. (Mathematics) Programme are as:

a. **Disciplinary Knowledge**: Capability of demonstrating comprehensive knowledge of basic concepts and ideas in mathematics and its subfields, and its applications to other disciplines.

b. **Communications skills:** Ability to communicate various concepts of mathematics in effective and coherent manner both in writing and orally, ability to present the complex mathematical ideas in clear, precise and confident way.

c. **Multidimensional thinking and analytical reasoning:** Ability to apply multidimensional thinking in understanding the concepts in mathematics and allied areas; identify relevant assumptions, hypothesis, implications or conclusions; formulate mathematically correct arguments; ability to analyse and generalise specific arguments or empirical data to get broader concepts.

d. **Problem solving**: Be able to apply mathematical skills and logical reasoning for solving different kinds of non-familiar problems. Capability to solve problems in computer graphics using concepts of linear algebra; linear programming, C, C++, Matlab, Maple and Mathematica. Capability to apply the knowledge gained from different areas of mathematics to solve specific problems or models in operations research, physics, chemistry, electronics, medicine, economics, finance etc.

e. **Research-related skills**: Capability to ask and inquire about relevant/appropriate questions, ability to define problems, formulate hypotheses, test hypotheses, formulate mathematical arguments and proofs, draw conclusions; ability to write clearly the results obtained.

f. **Self-directed learning**: Ability to work independently, ability to search relevant resources, capability to use ICT tools and e-content for self-learning and enhancing knowledge in mathematics.

g. **Moral and ethical awareness**: Ability to identify unethical behavior such as fabrication or misrepresentation of data, committing plagiarism, infringement of intellectual property rights.

h. **Employment**: Have sound knowledge of mathematical modelling, programming and computational techniques as required for employment in industry.

5. Qualification Descriptors for Integrated B.Sc.-M.Sc. (Mathematics) (Possible Career Pathways):

Students who choose Integrated B.Sc.-M.Sc. (Mathematics) programme, develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life. Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector, entrepreneurship and industry. The key importance is the theme of integrating mathematical and professional skills. The well-structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research. The qualification descriptors for Integrated B.Sc.-M.Sc. (Mathematics) programme may include the following:

i. Demonstrate fundamental/systematic and coherent knowledge of the academic field of mathematics and its applications and links to engineering, science, technology, economics and finance; demonstrate procedural knowledge that create different professionals like teachers and researchers in mathematics, quantitative analysts, actuaries, risk managers, professionals in industry and public services.
ii. Demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.
iii. Demonstrate comprehensive knowledge about materials, including scholarly, and/or professional literature, relating to essential learning areas pertaining to the field of mathematics, and techniques and skills required for identifying mathematical problems.
iv. Apply the acquired knowledge in mathematics and transferable skills to new/unfamiliar contexts and real-life problems.
v. Demonstrate mathematics-related and transferable skills that are relevant to some of the job trades in education sector, entrepreneurship and employment opportunities.

6. Structure of integrated B.Sc.-M.Sc. (Mathematics) Programme:

The Integrated B.Sc.-M.Sc. (Mathematics) programme is a five year course divided into 10 semesters. A student is required to have complete the credit as per University ordinance and UGC guidelines. The scheme and syllabus of the course are subject to change according to the UGC guidelines, NEP 2020 and University ordinance.

Duration: Integrated B.Sc.-M.Sc. (Mathematics) program is a full-time integrated program offered by the Department of Mathematics. This is a 5-years program, consisting of ten semesters with two semesters per year.

Eligibility: 10+2 in Science Streams or equivalent of any recognized board in India with Mathematics as one of the optional subjects having minimum 50% marks or equivalent grade in aggregate for UR category and 45% or equivalent grade for SC/ST/OBC/PWD/EWS candidates.

7. Course Type

Core Courses (CC)

Generic Elective Courses (GEC)

Discipline Specific Elective Courses (DSEC)

Skill Enhancement Courses (SEC)

Ability Enhancement Compulsory Courses (AECC)

Total Credit: Semester-wise distribution of credits: 22+ 22+ 28 + 28+24+24

CORE COURSES (CC)

S.No.	Course code	Course title	L	T	P	Credit
1.	SBSMAT 03 01 01 C 4046	Calculus (P)	4	0	4	6
2.	SBSMAT 03 01 02 C 5106	Algebra	5	1	0	6
3.	SBSMAT 03 02 01 C 5106	Real Analysis	5	1	0	6
4.	SBSMAT 03 02 02 C 4046	Differential Equations (P)	4	0	4	6
5.	SBSMAT 03 03 01 C 5106	Multivariable Calculus	5	1	0	6
6.	SBSMAT 03 03 02 C 5106	Group Theory	5	1	0	6
7.	SBSMAT 03 03 03 C 5106	Probability and Statistics	5	1	0	6
8.	SBSMAT 03 04 01 C 5106	Mechanics	5	1	0	6
9.	SBSMAT 03 04 02 C 5106	Linear Algebra	5	1	0	6
10.	SBSMAT 03 04 03 C 5106	Partial Differential Equations and Calculus of Varitation	5	1	0	6
11.	SBSMAT 03 05 01 C 5106	Set Theory and Metric Spaces	5	1	0	6
12.	SBSMAT 03 05 02 C 5106	Advanced Algebra	5	1	0	6
13.	SBSMAT 03 06 01 C 5106	Complex Analysis	5	1	0	6
14.	SBSMAT 03 06 02 C 4046	Numerical Analysis	4	0	4	6

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

(Offered to the Students of Integrated B.Sc.-M.Sc. (Mathematics) by the Department)

S.No.	Course code	Course title	L	T	P	Credit
1.	SBSMAT 03 05 01 DSE 5106	Tensors and Differential Geometry	5	1	0	6
2.	SBSMAT 03 05 02 DSE 5106	Mathematical Logic	5	1	0	6
3.	SBSMAT 03 05 03 DSE 5106	Integral Transforms and Fourier Analysis	5	1	0	6
4.	SBSMAT 03 05 04 DSE 5106	Linear Programming	5	1	0	6
5.	SBSMAT 03 05 05 DSE 5106	Information and Coding Theory	5	1	0	6
6.	SBSMAT 03 05 06 DSE 5106	Graph Theory	5	1	0	6
7.	SBSMAT 03 05 07 DSE 5106	Special Theory and Relativity	5	1	0	6
8.	SBSMAT 03 05 08 DSE 5106	Analytical Geometry	5	1	0	6
9.	SBSMAT 03 06 01 DSE 5106	Discrete Mathematics	5	1	0	6
10.	SBSMAT 03 06 02 DSE 5106	Wavelets and Applications	5	1	0	6
11.	SBSMAT 03 06 03 DSE 5106	Number Theory	5	1	0	6
12.	SBSMAT 03 06 04 DSE 5106	Mathematical Finance	5	1	0	6
13.	SBSMAT 03 06 05 DSE 5106	Cryptography	5	1	0	6
14.	SBSMAT 03 06 06 DSE 5106	Advanced Mechanics	5	1	0	6
15.	SBSMAT 03 06 07 DSE 5106	Dissertation on Any Topic of Mathematics	5	1	0	6

Note: Any MOOCs course for PG students on SWAYAM can also be taken as DCEC or GEC course on the recommendations of the department.

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)*:

Sr.	Course Code	Course Title	L	T	P	Credits
1.	SBSMAT 03 01 01 AECC 3104	Environmental Sciences	3	1	0	4
2.	SBSMAT 03 02 01 AECC 3104	प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)	3	1	0	4
3.	SBSMAT 03 02 02 AECC 3104	हिंदी भाषा : रचना एवं व्यवहार	3	1	0	4
4.	SBSMAT 03 02 03 AECC 3104	English	3	1	0	4

SKILL ENHANCEMENT ELECTIVE COURSES (SEC)*:

The department may offer more than one course depending on the specialization and strength of faculty members. The students have to opt for one course from Sr. 1 and 2 in 3rd semester and one from Sr. 3 and 4 in 4th semester from the following.

Sr.	Course Code	Course Title	L	T	P	Credits
1.	SBSMAT 03 03 01 SEC 3104	Logic, Sets and Graph Theory	3	1	0	4
2.	SBSMAT 03 03 02 SEC 3024	Computer Fundamentals and Programming in C	3	0	2	4
3.	SBSMAT 03 04 01 SEC 3024	Object Oriented Programming in C++(P)	3	0	2	4
4.	SBSMAT 03 04 02 SEC 3104	Linux Operating System and Computer Graphics	3	1	0	4

*** 1. University/Department may add more choices for Ability Enhancement Compulsory and Skill Enhancement Elective Courses.**

2. The AECC course Environmental Sciences **is compulsory, whereas one out of the remaining three AECC courses (प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च, हिंदी भाषा: रचना एवं व्यवहार and English/MIL) will be taught in first/second semester according to availability of faculty members in respective departments.**

****This scheme supersedes the earlier available scheme.**

8. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

Scheme and Syllabus of Integrated B.Sc.-M.Sc. in Mathematics

(CHOICE BASED CREDIT SYSTEM)

Semester I

Total credits: 22

S. No.	Course Title	Course Code	L	T	P	Credits
1	Calculus	SBSMAT 03 01 01 C 4046	4	0	4	6
2	Algebra	SBSMAT 03 01 02 C 5106	5	1	0	6
3	AECC1		3	1	0	4
4	GE 1		5	1	0	6

Semester II

Total credits: 22

S. No.	Course Title	Course Code	L	T	P	Credits
1	Real Analysis	SBSMAT 03 02 01 C 5106	5	1	0	6
2	Differential Equations	SBSMAT 03 02 02 C 4046	4	0	4	6
3	AECC2		3	1	0	4
4	GE 2		5	1	0	6

Semester III

Total credits: 28

S. No.	Course Title	Course Code	L	T	P	Credits
1	Multivariable Calculus	SBSMAT 03 03 01 C 5106	5	1	0	6
2	Group Theory	SBSMAT 03 03 02 C 5106	5	1	0	6
3	Probability and Statistics	SBSMAT 03 03 03 C 5106	5	1	0	6
4	SEC1		3	1/0	0/2	4
5	GE3		5	1	0	6

Semester IV

Total credits: 28

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mechanics	SBSMAT 03 04 01 C 5106	5	1	0	6
2	Linear Algebra	SBSMAT 03 04 02 C 5106	5	1	0	6
3	Partial Differential Equations and Calculus of Variation	SBSMAT 03 04 03 C 5106	5	1	0	6
4	SEC2		3	1/0	0/2	4
5	GE4		5	1	0	6

Semester V

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Set Theory and Metric Spaces	SBSMAT 03 05 01 C 5106	5	1	0	6
2	Advanced Algebra	SBSMAT 03 05 02 C 5106	5	1	0	6
3	DSE1		5	1	0	6
4	DSE2		5	1	0	6

Semester VI

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Complex Analysis	SBSMAT 03 06 01 C 5106	5	1	0	6
2	Numerical Analysis	SBSMAT 03 06 02 C 4046	4	0	4	6
3	DSE3		5	1	0	6
4	DSE4		5	1	0	6

COURSE-LEVEL LEARNING OUTCOMES

Course Structure

SEMESTER – I

<table>
<tr><td>Course No: 1</td><td colspan="5">Course Name: Calculus (P)</td><td colspan="3">Course Code: SBSMAT 03 01 01 C 4046</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td colspan="2">Total Hours: 120</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE:
TEE:</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, compactness, differentiability, and integrability, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical skill.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After going through this course the students will be able to
Understand the method of successive differentiation and Taylor series expansions.
Be familiar with concepts of asymptotes, curvature and singular points.
Apply the concepts of calculus for tracing and rectification of the curves in Cartesian, parametric and polar coordinates.
Understand reduction formulae and be familiar with the method of finding</td></tr>
</table>

	volumes and surfaces of solids of revolution.

Unit No.	Content of Each Unit	Hours of Each Unit
I	Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$ concavity and inflection points, asymptotes L'Hospitals rule, applications of maxima and minima.	30
II	Curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx\,dx$, $\int \cos nx\,dx$, $\int \tan nx\,dx$, $\int \sec nx\,dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x\,dx$ volume by slicing, disks and washer methods, volumes by cylindrical shells.	30
III	Parameterizing a curve, arc length, arc length of parametric curves and area of surface of revolution. Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.	30
IV	Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, connectedness.	30

Books Recommended:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005 **(Textbook).**
2. B. C. Das & B. N. Mukherjee, Differential Calculus, U. N. Dhur and Sons. Pvt. Ltd.
3. S. Narayan & P. K. Mittal, Integral Calculus, S. Chand Publishing, **(Textbook).**
4. S. Narayan & P. K. Narayan, A Text Book on Vector Calculus, S. Chand Publishing, (Textbook).
5. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi,2007.
6. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
7. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

List of Practical (using any software)

Plotting of graphs of function $e^{ax + b}$, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), |ax + b| and to illustrate the effect of a and b on the graph.

(i) Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.

(ii) Sketching parametric curves (E.g., Trochoid, cycloid, epicycloids and hypocycloid).

(iii) Obtaining surface of revolution of curves.

(iv) Tracing of conics in Cartesian coordinates/ polar coordinates.

(v) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid and hyperbolic paraboloid using Cartesian coordinates.

(vi) Matrix operations (addition, multiplication, inverse, transpose).

<table>
<tr><td>Course No: 2</td><td colspan="3">Course Name: Algebra</td><td colspan="5">Course Code: SBSMAT 03 01 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: N.A.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
Work with the trigonometric form of complex numbers including De-Moivre's formula.
Be familiar with the Euler form $re^{i\theta}$ of complex numbers
Apply the elementary operations on the matrices. Compute the eigenvalues, eigen function, characteristic equation and minimal polynomial of a given matrix.
Obtain the solution of the systems of linear equations using the concept of rank of matrices</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Equivalence relations, Functions, Composition of functions,</td><td colspan="2">23</td></tr>
</table>

	Invertible functions, One to one correspondence and cardinality of a set.	
II	Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.	22
III	Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.	23
IV	Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, Characterizations of invertible matrices. Subspaces of $\mathbf{R}^n$, dimension of subspaces $\mathbf{R}^n$ and rank of a matrix, Eigenvalues, Eigen Vectors and Characteristic Equation of a matrix.	22

Books Recommended:

1. Hall & Night, Higher Algebra, Arihant Publishers, 2013, **(Textbook).**
2. K. Hoffman, R.A. Kunze, Linerar Algebra 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.
3. S. L. Loney, Plane Trigonometry, Arihant Publishers, 2016.
4. D. C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007, **(Textbook).**
5. R.G. Bartle and D. R. Sherbert, Introduction to Real Ananlysis. Willy Std Edition, 2014.
6. B. Das & B N Mukherjee, Higher Trigonometry, U N Dhur & Sons, 2007.
7. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhauser,2006
8. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

<table>
<tr><td>Course No: 03</td><td colspan="4">Course Name: Environmental Sciences</td><td colspan="3">Course Code: SBSMAT 03 01 01 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="7">To aware the students the need for sustainable development, problems of pollution, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, the depletion of ozone layer, loss of biodiversity and need of worldwide efforts in its conservation.</td></tr>
<tr><td></td><td colspan="7">After going through this course the students will be able to
• Get the knowledge about trends of biological diversity and conservation strategies and thereafter be able to create awareness for its conservation and development.
• Understanding of issues concerning different natural resources will be helpful to find scientific solution based on participatory approach.
• Know about the local environmental issues, movements and an important role to minimize the impact of these aspects.
• Knowledge about the types of pollution and pollution control</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.</td><td>15</td></tr>
<tr><td>II</td><td colspan="6">Introduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem :- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic</td><td>15</td></tr>
</table>

	ecosystems.	
III	Introduction – Definition, value and types: genetic, species and ecosystem diversity. Bio- geographical classification and Hot-spots of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation.	15
IV	Definition, cause, effects and control measures of Air, Water, Soil, Marine and Noise pollution. Solid Waste Management: Causes, effects and control measures of wastes. Seventeen Sustainable Developmental Goals, Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, Public awareness.	15

Books Recommended:

1. Bharucha E, (2002) The Biodiversity of India, Mapin Publishing
2. Cao G, Orru R (2014) Current Environmental Issues and Challenges. 2014th edition; Springer
3. Cunningham W P, Cunningham M A (2008) Principles of Environment Science. Enquiry and Applications. 5th Edition. Tata McGraw Hill, New Delhi
4. Dash M C, Dash S P (2009) Fundamentals of Ecology. 3rd McGraw Hill Education
5. Gibbs J, Malcolm L, Sterling J (2008) Problem-Solving in Conservation Biology and Wildlife Management. 2nd ed. Wiley-Blackwell
6. Ginley D, Cahen, D (2011) Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press
7. Gilbert M (2007) An Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi
8. Khan I (2019) Forest Governance and Sustainable Resource Management. SAGE Publications. India.
9. Odum E P, Barrett W, (2005) Fundamentals of Ecology. 5th ed. Cengage Learning.
10. Sharma P D (2017) Ecology and Environment. 13th ed. Rastogi Publications
11. Thangadurai D, Ching G, Jeyabalan S, Islam S (2019) Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. United States: Apple Academic Press

<table>
<tr><td>Course No: 04</td><td colspan="3">Course Name: प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)</td><td colspan="4">Course Code: SBSMAT 03 01 02 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2026</td><td rowspan="2">Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:

TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course:</td></tr>
<tr><td>Course Objective /उद्देश्यः</td><td colspan="7">1. संस्कृतेतर-विषयाणामध्येतृभ्यः संस्कृताध्ययनाय सौकर्योत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां वेदादि-शास्त्राणामुपनिषदां च रुचिरुत्पादनम्; 3. संस्कृतेनोपनिबद्धानां नीतिवाक्यानां गीतायां वर्णितस्य कर्मयोगस्य च तत्त्व-संधारणाय यत्नः; 4. सामान्य-भाषाविज्ञानस्य परिचयः।</td></tr>
<tr><td></td><td colspan="7">पाठ्यक्रमाध्ययनस्य फलम् / Course Level Learning Outcome:

● अध्येतारः वेदादि-शास्त्राणामुपनिषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नशीलाः भवेयुः।
● व्यावहारिकदृष्ट्या संस्कृतज्ञानेन अन्यविषयाणामध्येतारः तत्तद् स्वविषयानुगुणं संस्कृतभाषायामुप- लभ्यमानानां ग्रन्थानां प्रति यत्नशीलाः स्युः।
● वेदोपनिषत्–गीता–नीतिशास्त्र–भाषाशास्त्रादीनां विषयाणां सम्यगध्ययनेनास्माकं पूर्वजानां वैदुष्येण परिचयः संजायेत।
● भारतीय-चिन्तनपरम्परायाः समृद्धिं ज्ञातुमयं पाठ्यक्रमः प्रकृष्टमाध्यमः संजायेत।</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">घटकम्-1: (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)</td><td>15</td></tr>
<tr><td>II</td><td colspan="6">घटकम्-2: भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः</td><td>15</td></tr>
</table>

III	**घटकम्-3:** भगवद्गीता – तृतीयाध्यायः (कर्मयोगः)	15
IV	**घटकम्-4:** सामान्यभाषाविज्ञानम्- (क) वर्णमाला, वर्णानाम् उच्चारणस्थानानि प्रयत्नाश्च; (ख) भाषाविज्ञानस्य सामान्यः परिचयः, भाषापरिवर्तनस्य कारणानि, अर्थपरिवर्तनस्य कारणानि च	15

अनुशंसितग्रन्थाः -

1. उवव्ट-महीधर, शुक्लयजुर्वेदभाष्य, मोतीलाल बनारसीदास, दिल्ली, 2007

2. स्वामी दयानन्द सरस्वती, यजुर्वेदभाष्य, सम्पा० ब्रह्मदत्त जिज्ञासु, रामलाल कपूर ट्रस्ट, सोनीपत (हरियाणा)

3. तैत्तिरीयोपनिषद्, हिन्दी व्याख्याकार - स्वामी प्रखर प्रज्ञानन्द सरस्वती, काशी, 2013

4. भर्तृहरि, नीतिशतक, सम्पादक एवं हिन्दी व्याख्याकार - जनार्दन शास्त्री पाण्डेय, मोतीलाल बनारसीदास, दिल्ली, 2014

5. नीतिशतकम्, 'नीतिपथ' हिन्दी व्याख्याकार - राजेश्वर शास्त्री मुसलगाँवकर, चौखम्भा, वाराणसी

6. श्रीमद्भगवद्गीता (हिन्दी अनुवाद सहित), गीता प्रैस, गोरखपुर, 2015

7. श्रीकृष्ण त्रिपाठी, श्रीमद्भगवद्गीता (द्वितीय, तृतीय एवं चतुर्थ अध्याय), 2005

8. देवीदत्त शर्मा, भाषिकी और संस्कृत भाषा, हरियाणा साहित्य अकादमी, चण्डीगढ़, 1990

9. कपिलदेव द्विवेदी, भाषा-विज्ञान एवं भाषा-शास्त्र, विश्वविद्यालय प्रकाशन, चौक, वाराणसी, 2012

10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ

11. Burrow, T., The Sanskrit Language, 2016

12. Gune, P.D., An Introduction to Comparative Philology, Oriental Book House, Poona, 1958

13. The Taittirīya Upaniṣad, Eng. Tr. and Commentary by Swami Muni Narayana Prasad, D.k. Print world (P), Ltd., New Delhi-2009

14. The NĪti and Vairāgya Śatakas of Bhartrihari, M.R. Kale, Motilal Banarsidass, Delhi, 2017

SEMESTER – II

<table>
<tr><td>Course No: 05</td><td colspan="4">Course Name: Real Analysis</td><td colspan="4">Course Code: SBSMAT 03 02 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td colspan="2">P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td colspan="2">0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="3">Examination Duration:</td><td colspan="4">3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighborhood of a point, countable sets , sequence and series, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After going through this course the students will be able to
Identify the properties of the number system and Describe various analytical properties of the real number system.
Explain the concept of sequences and their types and Identify the convergence of sequences and series of positive terms.
Apply various important convergence tests to the given series.
Understand the difference between conditional and absolute convergence of alternating series.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of</td></tr>
</table>

		Each Unit
I	Review of Algebraic and Order Properties of *R*, neighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property.	23
II	Density of Rational (and Irrational) numbers in *R*, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets. Sequences, Bounded sequence, Convergent sequence, Limit of a sequence.	23
III	Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.	22
IV	Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Test for Convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.	22

Books Recommended:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002, **(Textbook).**
2. I. Kumar and S. Kumarasen, A Basic Course in Real Analysis, CRC Press, 2014, **(Textbook).**
3. G. B. Thomas and R. L. Finney, Calculus, Pearson, 9th Ed, 2005.
4. G. G. Bilodeau , P. R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett,2010.
5. S. Thomson, A. M. Bruckner and J. B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
6. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.

<table>
<tr><td>Course No: 06</td><td colspan="4">Course Name: Differential Equations (P)</td><td colspan="3">Course Code: SBSMAT 03 02 02 C 4046</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme: Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td>Total Hours: 120</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE:

TEE:</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: N.A.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to introduce ordinary differential equations, general, particular, explicit, implicit and singular solutions of a differential equation. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
• Use the techniques to solve differential equations and apply these techniques in various mathematical models used in real life problems.
• Be familiar with formation of differential equations and to solve exact differential equations by finding integrating factors.
• Find solution of Lagrange's equations, Clairauts equations and other standard equations of first order but not of first degree.
• Learn the concept of auxiliary equation, particular integral for linear differential equations with constant co-efficients and their solution</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential</td><td>22</td></tr>
</table>

	equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.	
II	Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.	23
III	General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients.	23
IV	Euler's equation, method of undetermined coefficients, method of variation of parameters. Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.	22

List of Practical (using any software)

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only)
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).

11. Plotting of recursive sequences.
12. Study the convergence of sequences through plotting.

Books Recommended:

1. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004, **(Textbook).**
2. E. A. Coddington, An Introduction to Ordinary Differential Equation, Dover Publications, 1961, **(Textbook).**
3. G. R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York,2009.
4. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India,2005.
5. M. L. Abell, J. P. Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press,2004.

<table>
<tr><td>Course No: 07</td><td colspan="5">Course Name: हिंदी भाषा : रचना एवं व्यवहार .</td><td colspan="3">Course Code: SBSMAT 03 02 01 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE:

TEE:</td><td colspan="3">Examination Duration:</td><td colspan="3">3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="8">• भाषा, व्याकरण एवं साहित्य के सामान्य स्वरूप का निदर्शन।</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">• भाषा, बोली और व्याकरण के विविध घटकों का परिचय।
• संचार माध्यमों के स्वरूप और भाषा का ज्ञान।
• रचना पाठ से साहित्य बोध।</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">भाषा की परिभाषा एवं विशेषताएं
भाषा और व्याकरण
हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="6">हिंदी भाषा व बोलियों का संक्षिप्त परिचय
हिंदी की संवैधानिक स्थिति : राजभाषा, संपर्क भाषा और राष्ट्रभाषा
कार्यालयी हिंदी : पल्लवन, संक्षेपण, टिप्पण
पत्र लेखन : सरकारी, अर्द्ध-सरकारी</td><td colspan="2">15</td></tr>
</table>

III	संचार माध्यमों का स्वरूप एवं भाषा संचार माध्यमों का सामाजिक प्रभाव कंप्यूटर में हिंदी का अनुप्रयोग	15
IV	**कहानी : चंद्रधर शर्मा 'गुलेरी' :** उसने कहा था; **प्रेमचंद :** नशा **निबंध : हजारी प्रसाद द्विवेदी :** नाखून क्यों बढ़ते हैं; **बालमुकुंद गुप्त :** बनाम लार्ड कर्जन **कविता : सूर्यकांत त्रिपाठी 'निराला' :** वर दे, वीणा वादिनी वर दे ! **जयशंकर प्रसाद :** हिमाद्रि तुंग शृंग से	15

अनुशंसित पुस्तकें :

1. हिंदी : उद्भव, विकास और रूप; डॉ हरदेव बाहरी; किताब महल इलाहाबाद; 1969.
2. हिंदी भाषा; डॉ भोलानाथ तिवारी; किताब महल, इलाहाबाद; 2004.
3. हिंदी व्याकरण; कामता प्रसाद गुप्त; नागरी प्रचारिणी सभा, काशी; 1927.
4. व्यावहारिक हिंदी व्याकरण तथा रचना; हरदेव बाहरी; लोकभारती प्रकाशन, इलाहाबाद; 1972.
5. कंप्यूटर और हिंदी; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2015.
6. रेडियो और दूरदर्शन पत्रकारिता; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2017.

<table>
<tr><td>Course No: 08</td><td colspan="4">Course Name: English</td><td colspan="3">Course Code: SBSMAT 03 02 02 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:

TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="7">The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills which should be integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills. Some of these are:
Language of communication, various speaking skills such as personal communication, social interactions and communication in professional situations such as interviews, group discussions and office environments, important reading skills as well as writing skills such as report writing, notetaking etc.
While, to an extent, the art of communication is natural to all living beings, in today’s world of complexities, it has also acquired some elements of science. It is hoped that after studying this course, students will find a difference in their personal and professional interactions.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of</td></tr>
</table>

		Each Unit
I	Introduction: Theory of Communication, Types and modes of Communication. Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication	15
II	Speaking Skills: Monologue Dialogue, Group Discussion, Effective Communication/ Mis- Communication, Interview Public Speech	15
III	Reading and Understanding, Close Reading, Comprehension Summary, Paraphrasing, Analysis and Interpretation, Translation(from Indian language to English and vice-versa) ,Literary/Knowledge Texts	15
IV	Writing Skills, Documenting, Report Writing, Making notes, Letter writing	15

Books Recommended :

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brati Biswas

SEMESTER – III

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 03 01 C 5106	Multivariable Calculus	6	105	45	-	150
SBSMAT 03 03 02 C 5106	Group Theory	6	105	45	-	150
SBSMAT 03 03 03 C 5106	Probability and Statistics	6	105	45	-	150
SEC1		4	70	30	-	100
GE3		6	105	45	-	150
Total marks of Semester-III						700

<table>
<tr><td>Course No: 09</td><td colspan="3">Course Name: Multivariable Calculus</td><td colspan="4">Course Code: SBSMAT 03 03 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
Learn conceptual variations while advancing from one variable to several variables in calculus.
Apply multivariable calculus in optimization problems.
Inter-relationship amongst the line integral, double and triple integral formulations.
Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.
Realize importance of Green, Gauss and Stokes’ theorems in other branches of mathematics.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td colspan="7">Unit-I: Partial Differentiation
Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Differentiation</td><td>18</td></tr>
</table>

Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables and more variables, Envelopes and evolutes.	
Unit-III: Extrema of Functions and Vector Field Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems, Definition of vector field, Divergence, curl, gradient and vector identities.	18
Unit-IV: Double and Triple Integrals Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals, Dirichlet integral.	18
Unit-V: Green's, Stokes' and Gauss Divergence Theorem Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.	18

References:

1. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited.
2. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage, **(Textbook).**
3. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition). Pearson Education. Dorling Kindersley (India) Pvt. Ltd.
4. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). Thomas' Calculus (14th edition). Pearson Education, **(Textbook).**

<table>
<tr><td>Course No: 10</td><td colspan="3">Course Name: Group Theory</td><td colspan="5">Course Code: SBSMAT 03 03 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce basic structures of algebra like group, dihedral groups, permutation group, Abelian group, non-Abelian group and cyclic group which are the main pillars of modern group theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Recognize the mathematical objects called groups.
Link the fundamental concepts of groups and symmetries of geometrical objects.
Explain the significance of the notions of cosets, normal subgroups, and factor groups.
Analyze consequences of Lagrange's theorem.
Learn about structure preserving maps between groups and their consequences.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Groups and its Elementary Properties
Symmetries of a square, Definition and examples of groups including dihedral, permutation and quaternion groups, Elementary properties of groups.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Subgroups and Cyclic Groups
Subgroups and examples of subgroups, Cyclic groups, Properties of cyclic groups, Lagrange's theorem, Euler phi function, Euler's theorem, Fermat's little theorem.</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Normal Subgroups
Properties of cosets, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Classification of subgroups of cyclic groups.</td><td>18</td></tr>
</table>

Unit-IV: Permutation Groups Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups, Cayley's theorem and its applications.	18
Unit-V: Group Homomorphisms, Rings and Fields Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Properties of isomorphisms; First, second and third isomorphism theorems for groups; Definitions and elementary properties of rings and fields.	18

References:

1. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage, **(Textbook).**
2. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson **(Textbook)**.
3. Michael Artin (2014). Algebra (2nd edition). Pearson.
4. I.N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
5. Nathan Jacobson (2009). Basic Algebra I (2nd edition). Dover Publications.
6. Ramji Lal (2017). Algebra 1: Groups, Rings, Fields and Arithmetic. Springer.
7. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.

<table>
<tr><td>Course No: 11</td><td colspan="3">Course Name: Probability and Statistics</td><td colspan="5">Course Code: SBSMAT 03 03 03 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses. After taking this course, students will be able to use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB, to perform simple and sophisticated analyses for large samples.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Understand distributions in the study of the joint behaviour of two random variables.
• Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
• Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I: Probability Functions and Moment Generating Function Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.	18
Unit-II: Univariate Discrete and Continuous Distributions Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.	18

Unit-III: Bivariate Distribution Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.	18
Unit-IV: Correlation, Regression and Central Limit Theorem The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.	18
Unit-V: Modeling Uncertainty Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.	18

References:

1. Irwin Miller &Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India, **(Textbook).**
2. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.
6. V.K. Kapoor and S. C. Gupta (2018). Fundamental of Mathematical Statistics, S. Chand & Sons.

<table>
<tr><td>Course No: 12</td><td colspan="3">Course Name:
Logic, Sets and Graph Theory</td><td colspan="5">Course Code: SBSMAT 03 03 01 SEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce students with the fundamental concepts in set, logic and graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Analyze the truth and falsity of a logical statement and differentiate between a logical statement and an ordinary statement.
Define and describe various properties of sets.
Describe the fundamental properties of Graph Theory.
Identify different representations of a Graph for practical applications.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Logic
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.</td><td>12</td></tr>
<tr><td colspan="8">Unit-II: Set Theory
Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.</td><td>12</td></tr>
</table>

Unit-III: Relation on Sets Difference and Symmetric difference of two sets. Set identities, generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.	12
Unit-IV: Graph Theory Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles.	12
Unit-V: Application of Graph Theory The adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd- Warshall algorithm, Tree, Binary tree, rooted tree, spanning tree.	12

References:

1. Rosen, K. H. Discrete Mathematics and Its Applications. 7th edition, Tata McGraw Hill, 2011, **(Textbook).**
2. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003, **(Textbook).**
3. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education,2018.
4. Lipschutz, S., Lipson, M.L. and Patil, V.H. *Discrete Mathematics.* Schaum's Outline Series, Tata McGraw-Hill Education, 2020.
5. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge,1990.

<table>
<tr><td colspan="2">Course No: 13</td><td colspan="2">Course Name: Computer Fundamentals and Programming in C</td><td colspan="5">Course Code: SBSMAT 03 03 02 SEC 3024</td></tr>
<tr><td rowspan="2" colspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 75</td></tr>
<tr><td colspan="2">Course Objective</td><td colspan="7">To familiarize the students with problem solving through C-programming. The course aims to give exposure to basic concepts of the C-programming. The lab component of this course is designed to provide hands-on-training with the concepts.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Write and run a C program along with gradual improvement using efficient error handling.
Implement selective structures and repetitive structures in C programs using different control statements.
To emphasize on the importance of use of pointers for efficient C programming.
Use structures and unions in a C program for handling multivariate data.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: C Language Preliminaries

An overview of Programming, Programming Language, Classification. Basic structure of a C Program, C language preliminaries. Operators and Expressions, Bit - Manipulation Operators, Bitwise Assignment Operators, Decisions and looping.</td><td>15</td></tr>
<tr><td colspan="8">Unit-II: Arrays and Pointers
Arrays and Pointers, Encryption and Decryption. Pointer Arithmetic, Passing Pointers as Function Arguments, Accessing Array Elements through Pointers, Passing Arrays as Function Arguments. Multidimensional Arrays. Arrays of Pointers, Pointers to Pointers.</td><td>15</td></tr>
</table>

Unit-III: Storage Classes Storage Classes –Fixed vs. Automatic Duration. Scope. Global Variables. Definitions and Allusions. The Register Specifier. ANSI rules for the Syntax and Semantics of the Storage Class Keywords.	15
Unit-IV: Structures and Unions Dynamic Memory Allocation. Structures and Unions. enum declarations. Passing Arguments to a Function, Declarations and Calls, Automatic Argument Conversions, Pointers to Functions.	15
Unit-V: C Preprocessors The C Preprocessors, Macro Substitution. Include Facility. Conditional Compilation. Line Control. Input and Output -Streams. Buffering. Error Handling. Opening and Closing a File. Reading and Writing Data. Selecting an I/O Method. Unbuffered I/O. Random Access. The Standard Library for I/O.	15

References:

1. Y. Kanetkar (2020), Let us C, 15th edition, BPB Publication, **(Textbook)**.
2. Brian W. Kernighan & Dennis M. Ritchie, The C Program Language, Second Edition (ANSI features), Prentice Hall 2019.
3. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 2003.
4. Samuel P. Harkison and Gly L. Steele Jr., C: A Reference Manual, Second Edition, Prentice Hall, 2014.
5. Balagurusamy E: Programming in ANSI C, Third Edition, Tata McGraw-Hill Publishing Co. Ltd., 2018.
6. Byron, S. Gottfried: Theory and Problems of Programming with C, Second Edition (Schaum Outline Series), Tata McGraw-Hill Publishing Co. Ltd., 2017.
7. Venugopal K. R. and Prasad S. R.: Programming with C , Tata McGraw-Hill Publishing Co. Ltd., 2020.

Course No: **14**	**Course Name:** ******** GE3		**Course Code:** ******* GE 5106				
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: III**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – IV

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 04 01 C 5106	Mechanics	6	105	45	-	150
SBSMAT 03 04 02 C 5106	Linear Algebra	6	105	45	-	150
SBSMAT 03 04 03 C 5106	Partial Differential Equations and Calculus of Variation	6	105	45	-	150
SEC1		4	70	30		100
GE4		6	105	45	-	150
Total marks of Semester-IV						700

<table>
<tr><td>Course No: 15</td><td colspan="3">Course Name: Mechanics</td><td colspan="4">Course Code: SBSMAT 03 04 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Familiarize with subject matter, which has been the single centre, to which wer drawn mathematicians, physicists, astronomers, and engineers together.
• Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.
• Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.
• Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
• Learn that a particle moving under a central force describes a plane curve and know the Kepler’s laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Statics
Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.</td><td>18</td></tr>
</table>

Unit-II: Centres of Gravity and Common Catenary Centres of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.	18
Unit-III: Rectilinear Motion Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity, Motion of varying mass.	18
Unit-IV: Motion in a Plane Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates; Motion in a vertical circle, projectiles in a vertical plane and cycloidal motion.	18
Unit-V: Central Orbits Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion.	18

References:

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books, **(Textbook).**
2. P. L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad,
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill**.**
4. A. S. Ramsey (2009). Statics. Cambridge University Press.
5. A. S. Ramsey (2009). Dynamics. Cambridge University Press.
6. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd.

<table>
<tr><td colspan="1">Course No: 16</td><td colspan="2">Course Name: Linear Algebra</td><td colspan="6">Course Code: SBSMAT 03 04 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation, vector space, linear transformation and inner product spaces which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
Relate matrices and linear transformations, compute eigen values and eigen vectors of linear transformations.
Learn properties of inner product spaces and determine orthogonality in inner product spaces.
Realise importance of adjoint of a linear transformation and its canonical form.</td></tr>
</table>

Content of Each Unit	**Hours**
Unit-I: Vector Spaces Definition and examples, Subspace, Linear span, Quotient space and direct sum of subspaces, Linearly independent and dependent sets, Bases and dimension.	18
Unit-II: Linear Transformations Definition and examples, Algebra of linear transformations, Matrix of a linear transformation, Change of coordinates, Rank and nullity of a linear transformation and rank-nullity theorem.	18
Unit-III: Further Properties of Linear Transformations Isomorphism of vector spaces, Isomorphism theorems, Dual and second dual of a vector space, Transpose of a linear transformation, Eigen vectors and eigen values of a linear transformation, Characteristic polynomial and Cayley-Hamilton theorem, Minimal polynomial.	18

Unit-IV: Inner Product Spaces Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalisation, Diagonalisation of symmetric matrices.	18
Unit-V: Adjoint of a Linear Transformation and Canonical Forms Adjoint of a linear operator; Hermitian, unitary and normal linear transformations; Jordan canonical form, Triangular form, Trace and transpose, Invariant subspaces.	18

References:

1. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra, (4thedition). Prentice-Hall of India Pvt. Ltd, **(Textbook).**
2. Vivek Sahai & Vikas Bist (2013). Linear Algebra (2nd Edition). Narosa Publishing House, **(Textbook).**
3. Kenneth Hoffman & Ray Kunze (2015). Linear Algebra (2nd edition). Prentice-Hall.
4. M. Gel'fand (1989). Lectures on Linear Algebra. Dover Publications.
5. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
6. Serge Lang (2005). Introduction to Linear Algebra (2nd edition). Springer India.
7. Gilbert Strang (2014). Linear Algebra and its Applications (2nd edition). Elsevier.

<table>
<tr><td>Course No: 17</td><td colspan="3">Course Name: Partial Differential Equations and Calculus of Variations</td><td colspan="5">Course Code: SBSMAT 03 04 03 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce partial differential equations, general, particular, explicit, implicit and singular solutions of a partial differential equation. This course further explains the analytic techniques in computing the solutions of various partial differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Apply a range of techniques to solve first & second order partial differential equations.
• Model physical phenomena using partial differential equations such as the heat and wave equations.
• Understand problems, methods and techniques of calculus of variations.</td></tr>
</table>

Content of Each Unit	**Hours**
Unit-I: First Order Partial Differential Equations Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.	18
Unit-II: Second Order Partial Differential Equations with Constant Coefficients Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients.	18
Unit-III: Second Order Partial Differential Equations with Variable Coefficients Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDE, Reduction to canonical or normal form; Monge's method; Solution of heat and wave equations in one and two dimensions by method of separation of variables.	18

Unit-IV: Calculus of Variations-Variational Problems with Fixed Boundaries Euler's equation for functional containing first order and higher order total derivatives, Functionals containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.	18
Unit-V: Calculus of Variations-Variational Problems with Moving Boundaries Variational problems with moving boundaries, Functionals dependent on one and two variables, One sided variations. Sufficient conditions for an extremum-Jacobi and Legendre conditions, Second variation.	18

References:

1. I. N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications, **(Textbook).**
2. A. S. Gupta (2004). Calculus of Variations with Applications. PHI Learning, **(Textbook).**
3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
4. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equation for Scientists and Engineers (4th edition). Springer India**.**
5. H. T. H. Piaggio (2004). An Elementary Treatise on Differential Equations and Their Applications. CBS Publishers.
6. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.
7. L.C. Evans (2014), Partial Differential Equations, American Mathematical Society, Indian 2nd edition.

<table>
<tr><td>Course No: 18</td><td colspan="3">Course Name: Object Oriented Programming in C++</td><td colspan="5">Course Code: SBSMAT 03 04 01 SEC 3024</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td colspan="2">Total Hours: 75</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Write C++-Programs to solve Mathematical problems.
• Design algorithms to solve problems.
• Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism.
• Emphasize on the importance of use of Friend Functions for efficient C++ programming.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I Characteristics of Object-Oriented Programming Languages OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.	15
Unit-II Implementing OOPS Concepts in C++ Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables withFunctions.	15
Unit-III Abstract Data Types Abstract data types, Class Component, Object & Class, Constructors Default and Copy	15

Constructor, Assignment operator deep and shallow coping, Access modifiers – private, public and protected.	
Unit-IV Implementing Class Functions Implementing Class Functions within Class declaration or outside the Class declaration. Instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members. Understanding Compile Time, Polymorphism, function overloading, Rules of Operator Overloading (Unary and Binary) as member function/friend function,	15
Unit-V Implementation of Operator Overloading Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator, concepts of namespaces.	15

References:

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997, **(Textbook).**
2. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000, **(Textbook).**
3. B. Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, Object Oriented Programming with C++, BPB Publication.
5. B. Stroustrup , The C++ Programming Language, 3rd Ed., Addison Welsley.

Course No: 19	Course Name: Linux Operating System and Computer Graphics						Course Code: SBSMAT 03 04 02 SEC 3104	
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** IV	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 04**
			3	1	0	4	**Total Hours: 60**
Course Objective	This course introduces the Role and purpose of the operating system, Functionality of a typical operating system, managing atomic access to OS objects. Detailed study of computer graphics, 2 D and 3 D transformations, representations and visualization.						
Course Outcomes	After going through this course the students will be able to • Test the Linux process model and explain how Linux schedule processes and provide inter- process communication • Explore how linux implements files systems and manages input output devices. • Identify the core concepts of computer graphics • Apply graphics programming techniques to create and design computer graphics scans						

Content of Each Unit	**Hours**
Unit-I Linux – The Operating System Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security.	12
Unit-II Linux – The General Characteristics The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.	12

Unit-III Resource Management in Linux Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.	12
Unit-IV Development of Computer Graphics Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices.	12
Unit-V Computer Graphics of Conic-Section Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.	12

References:

1. A. Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education,2008, **(Textbook).**
2. K. Cox, Red Hat Linux Administrator's Guide, PHI,2009, **(Textbook).**
3. R. Stevens, UNIX Network Programming, 3rd Ed., PHI,2008.
4. S. Das, Unix Concepts and Applications, 4th Ed., TMH,2009.
5. E. Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed., O'Reilly Media,2009.
6. N. Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed.,2004.
7. D. Hearn and M.P. Baker, Computer Graphics, 2nd Ed., Prentice–Hall of India,2004.
8. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, Computer Graphics: Principals and Practices, 2nd Ed., Addison-Wesley, MA,1990.
9. D.F. Rogers, Procedural Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 2001.
10. D.F. Rogers and A.J. Admas, Mathematical Elements in Computer Graphics, 2nd Ed., McGraw Hill, 1990.

<table>
<tr><td>Course No: 20</td><td colspan="2">Course Name: ******** GE4</td><td colspan="6">Course Code: ******* GE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
</table>

SEMESTER – V

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 05 01 C 5106	Set Theory and Metric Spaces	6	105	45	-	150
SBSMAT 03 05 02 C 5106	Advanced Algebra	6	105	45	-	150
DSE1		6	105	45	-	150
DSE2		6	105	45	-	150
Total marks of Semester-V						600

<table>
<tr><td>Course No: 21</td><td colspan="3">Course Name:
Set Theory and Metric Spaces</td><td colspan="6">Course Code: SBSMAT 03 05 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="3">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="9">To providing the basic knowledge pertaining to metric spaces such as open and closed balls, neighborhood, interior, closure, subspace, continuity, compactness, connectedness etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">After going through this course the students will be able to
Learn basic facts about the cardinality of a set.
Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano-Weierstrass property, compactness, and connectedness.
Identify the continuity of a function defined on metric spaces and homeomorphisms</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="8">Unit-I: Theory of Sets
Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder-Bernstein theorem, Cantor’s theorem, Order relation in cardinal numbers, Arithmetic of cardinal numbers, Partially ordered set, Zorn’s lemma and Axiom of choice, Various set theoretic paradoxes.</td><td colspan="2">18</td></tr>
<tr><td colspan="8">Unit-II: Concepts in Metric Spaces
Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.</td><td colspan="2">18</td></tr>
</table>

Unit-III: Complete Metric Spaces and Continuous Functions Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle.	18
Unit-IV: Compactness and Connectedness Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces. Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.	18
Unit-V: Riemann and Improper integral Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems. Improper integrals, Dirichlet test and Abel's test for improper integrals.	18

References:

1. E. T. Copson (1988). Metric Spaces. Cambridge University Press, **(Textbook).**
2. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa, **(Textbook).**
3. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa**, (Textbook).**
4. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
5. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.
6. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-Hill.
7. P. R. Halmos (1974). Naive Set Theory. Springer.

<table>
<tr><td>Course No: 22</td><td colspan="3">Course Name: Advanced Algebra</td><td colspan="5">Course Code: SBSMAT 03 05 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
</table>

Course Objective	The objective of the course is to introduce modern structures of algebra like group actions, orbits and stabilizers, rings and fields, field extensions and finite fields which are the main pillars of modern algebra. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.
Course Outcomes	After going through this course the students will be able to • Understand the basic concepts of group actions and their applications. • Recognize and use the Sylow theorems to characterize certain finite groups. • Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields. • Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.

Content of Each Unit	**Hours**
Unit-I: Group Actions Group actions, Orbits and stabilizers, Conjugacy classes, Orbit-stabilizer theorem, Normalizer of an element of a group, Center of a group, Class equation of a group, Inner and outer automorphisms of a group.	18
Unit-II: Sylow Theorems Cauchy's theorem for finite abelian groups, Finite simple groups, Sylow theorems and applications including nonsimplicity tests.	18

Unit-III: Rings and Fields Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, principal and maximal ideals, Relation between integral domain and field, Euclidean rings and their properties, Wilson and Fermat's theorems.	18
Unit-IV: Polynomial Rings Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain.	18
Unit-V: Field Extensions and Finite Fields Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Perfect field, Classification of finite fields.	18

References:

1. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley, **(Textbook)**.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press, **(Textbook).**
3. Michael Artin (2014). Algebra (2nd edition). Pearson.
4. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
6. N. S. Gopalakrishnan (1986). University Algebra, New Age International Publishers.
7. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
8. Thomas W. Hungerford (2004). Algebra (8th edition). Springer.
9. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
10. Serge Lang (2002). Algebra (3rd edition). Springer-Verlag.
11. I. S. Luthar & I. B. S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
12. I. S. Luthar & I. B. S. Passi (2012). Algebra: Volume 2: Rings. Narosa.

<table>
<tr><td>Course No: 23</td><td colspan="3">Course Name: Tensors and Differential Geometry</td><td colspan="5">Course Code: SBSMAT 03 05 01 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Explain the basic concepts of tensors.
Understand role of tensors in differential geometry.
Learn various properties of curves including Frenet-Serret formulae and their applications.
Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae.
Understand the role of Gauss’s Theorem a Egregium and its consequences.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I: Tensors
Contravariant and covariant vectors, Transformation formulae, Tensor product of two vector spaces, Tensor of type (r, s), Symmetric and skew-symmetric properties, Contraction of tensors, Quotient law, Inner product of vectors.</td><td colspan="2">18</td></tr>
<tr><td colspan="7">Unit-II: Further Properties of Tensors
Fundamental tensors, Associated covariant and contravariant vectors, Inclination of two vectors and orthogonal vectors, Christoffel symbols, Law of transformation of Christoffel symbols, Covariant derivatives of covariant and contravariant vectors, Covariant differentiation of tensors, Curvature tensor, Ricci tensor, Curvature tensor identities.</td><td colspan="2">18</td></tr>
</table>

Unit-III: Curves in $\mathbb{R}^2$ and $\mathbb{R}^3$ Basic definitions and examples, Arc length, Curvature and the Frenet-Serret formulae, Fundamental existence and uniqueness theorem for curves, Non-unit speed curves.	18
Unit-IV: Surfaces in $\mathbb{R}^3$ Basic definitions and examples, The first fundamental form, Arc length of curves on surfaces, Normal curvature, Geodesic curvature, Gauss and Weingarten formulae, Geodesics, Parallel vector fields along a curve and parallelism.	18
Unit-V: Geometry of Surfaces The second fundamental form and the Weingarten map; Principal, Gauss and mean curvatures; Isometries of surfaces, Gauss's Theorem Egregium, The fundamental theorem of surfaces, Surfaces of constant Gauss curvature, Exponential map, Gauss lemma, Geodesic coordinates, The Gauss-Bonnet formula and theorem.	18

References:

1. Alferd Gray (2018). Modern Differential Geometry of Curves and Surfaces with Mathematica (4th edition). Chapman & Hall/CRC Press, Taylor & Francis, **(Textbook).**
2. A. Pressley ().Elementary Differential Geometry. 2nd edition, Springer, **(Textbook)**.
3. Christian Bär (2010). Elementary Differential Geometry. Cambridge University Press.
4. Manfredo P. do Carmo (2016). Differential Geometry of Curves & Surfaces (Revised and updated 2nd edition). Dover Publications.
5. Richard S. Millman & George D. Parkar (1977). Elements of Differential Geometry. Prentice-Hall.
6. R. S. Mishra (1965). A Course in Tensors with Applications to Riemannian Geometry. Pothishala Pvt. Ltd**.**
7. Sebastián Montiel & Antonio Ross (2009). Curves and Surfaces. American Mathematical Society.

<table>
<tr><td>Course No: 24</td><td colspan="3">Course Name: Mathematical Logic</td><td colspan="5">Course Code: SBSMAT 03 05 02 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objective of the course is to introduce basic structures of language, propositional logic, completeness theorem and Interpretation in a theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Learn the syntax of first-order logic and semantics of first-order languages.
• Understand the propositional logic and basic theorems like compactness theorem, meta theorem and post-tautology theorem.
• Assimilate the concept of completeness interpretations and their applications with special emphasis on applications in algebra.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I: Syntax of First-order Logic First-order languages, Terms of language, Formulas of language, First order theory.	18
Unit-II: Semantics of First-order Languages Structures of first order languages, Truth in a structure, Model of a theory, Embeddings and isomorphism.	18
Unit-III: Propositional Logics Syntax of propositional logic, Semantics of propositional logic, Compactness theorem for propositional logic, Proof in propositional logic, Meta theorem in propositional logic, Post tautology theorem.	18

Unit-IV: Proof and Meta Theorems in First-order Logic Proof in first-order logic, Meta theorems in first-order logic, Some meta theorem in arithmetic, Consistency and completeness.	18
Unit-V: Completeness Theorem and Model Theory Completeness theorem, Interpretation in a theory, Extension by definitions, Compactness theorem and applications, Complete theories, Applications in algebra.	18

References:

1. Elliott Mendelson (2015). Introduction to Mathematical Logic (6th edition). Chapman & Hall/CRC, **(Textbook).**
2. Shashi Mohan Srivastava (2013). A Course on Mathematical Logic (2nd edition). Springer, **(Textbook).**
3. Richard E. Hodel (2013). An Introduction to Mathematical Logic. Dover Publications.
4. Yu I. Manin (2010). A Course in Mathematical Logic for Mathematicians (2nd edition). Springer.

<table>
<tr><td>Course No: 25</td><td colspan="3">Course Name: Integral Transforms and Fourier Analysis</td><td colspan="5">Course Code: SBSMAT 03 05 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course is aimed at exposing the students to learn the Laplace transforms and Fourier transforms. To equip with the methods of finding Laplace transform and Fourier Transforms of different functions. To make them familiar with the methods of solving differential equations, partial differential equations, IVP and BVP using Laplace transforms and Fourier transforms.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Know about piecewise continuous functions, Dirac delta function, Laplace transforms and its properties.
• Solve ordinary differential equations using Laplace transforms.
• Familiarise with Fourier transforms of functions belonging to $L^1(\mathbb{R})$ class, relation between Laplace and Fourier transforms.
• Explain Parseval's identity, Plancherel's theorem and applications of Fourier transforms to boundary value problems.
• Learn Fourier series, Bessel's inequality, term by term differentiation and integration of Fourier series.
• Apply the concepts of the course in real life problems.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I: Laplace Transforms Laplace transform, Linearity, Existence theorem, Laplace transforms of derivatives and integrals, Shifting theorems, Change of scale property, Laplace transforms of periodic functions, Dirac's delta function.	18

Unit-II: Further Properties of Laplace Transforms and Applications Differentiation and integration of transforms, Convolution theorem, Integral equations, Inverse Laplace transform, Lerch's theorem, Linearity property of inverse Laplace transform, Translations theorems of inverse Laplace transform, Inverse transform of derivatives, Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations.	18
Unit-III: Fourier Transforms Fourier and inverse Fourier transforms, Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Linearity property, Change of scale property, Shifting property, Modulation theorem, Relation between Fourier and Laplace transforms.	18
Unit-IV: Solution of Equations by Fourier Transforms Solution of integral equation by Fourier sine and cosine transforms, Convolution theorem for Fourier transform, Parseval's identity for Fourier transform, Plancherel's theorem, Fourier transform of derivatives, Applications of infinite Fourier transforms to boundary value problems, Finite Fourier transform, Inversion formula for finite Fourier transforms.	18
Unit-V: Fourier Series Fourier cosine and sine series, Fourier series, Differentiation and integration of Fourier series, Absolute and uniform convergence of Fourier series, Bessel's inequality, The complex form of Fourier series.	18

References:

1. James Ward Brown & Ruel V. Churchill (2011). Fourier Series and Boundary Value Problems. McGraw-Hill Education, **(Textbook).**
2. Walter Rudin (2017). Fourier Analysis on Groups. Dover Publications, **(Textbook).**
3. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press.
4. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley,.
5. A. Zygmund (2002).Trigonometric Series (3rd edition). Cambridge University Press.

Course No: 26	Course Name: Linear Programming						Course Code: SBSMAT 03 05 04 DSE 5106
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, Assignment and Game Problem. Such problems arise in manufacturing resource planning and financial sectors.						
Course Outcomes	After going through this course the students will be able to • Analyze and solve linear programming models of real life situations. • Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex set and extreme points. • Understand the theory of the simplex method. • Know about the relationships between the primal and dual problems, and to understand sensitivity analysis. • Learn about the applications to transportation, assignment and two-person zero-sum game problems.						

Content of Each Unit	Hours
Unit-I: Linear Programming Problem, Convexity and Basic Feasible Solutions Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.	18
Unit-II: Simplex Method Optimality criterion, Improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.	18

Unit-III: Duality Formulation of the dual problem, Duality theorems, Complimentary slackness theorem, Economic interpretation of the dual, Dual-simplex method.	18
Unit-IV: Sensitivity Analysis Changes in the cost vector, right-hand side vector and the constraint matrix of the linear programming problem.	18
Unit-V: Applications Transportation Problem: Definition and formulation, Methods of finding initial basic feasible solutions: Northwest-corner rule, Least- cost method, Vogel approximation method; Algorithm for obtaining optimal solution. Assignment Problem: Mathematical formulation and Hungarian method.Game Theory: Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method for solving a game.	18

References:

1. G. Hadley (2002). Linear Programming. Narosa Publishing House, **(Textbook).**
2. Hamdy A. Taha (2017). Operations Research: An Introduction (10th edition). Pearson, **(Textbook).**
3. Frederick S. Hillier & Gerald J. Lieberman (2015). Introduction to Operations Research (10th edition). McGraw-Hill Education.
4. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali (2010). Linear Programming and Network Flows (4th edition). John Wiley & Sons.
5. Paul R. Thie & Gerard E. Keough (2014). An Introduction to Linear Programming and Game Theory (3rd edition). Wiley India Pvt. Ltd.

<table>
<tr><td>Course No: 27</td><td colspan="3">Course Name:
Information and Coding Theory</td><td colspan="5">Course Code: SBSMAT 03 05 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The Mathematics program promotes mathematical skills and knowledge for their intrinsic beauty, effectiveness in developing proficiency in analytical reasoning, and utility in modeling and solving real world problems. Students who have learned to logically question assertions, recognize patterns, and distinguish the essential and irrelevant aspects of problems can think deeply and precisely, nurture the products of their imagination to fruition in reality, and share their ideas and insights while seeking and benefiting from the knowledge and insights of others.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Study simple ideal statistical communication models.
• Understand the development of codes for transmission and detection of information.
• Learn about the input and output of a signal via transmission channel.
• Study detection and correction of errors during transmission.
• Represent a linear code by matrices - encoding and decoding.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Concepts of Information Theory
Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Entropy Function
A sketch of communication network, Entropy, Basic relationship among different entropies, A measure of mutual information, Interpretation of Shannon’s fundamental</td><td>18</td></tr>
</table>

inequalities; Redundancy, efficiency, and channel capacity; Binary symmetric channel, Binary erasure channel, Uniqueness of the entropy function, Joint entropy and conditional entropy, Relative entropy and mutual information, Chain rules for entropy, Conditional relative entropy and conditional mutual information, Jensen's inequality and its characterizations, The log sum inequality and its applications.	
Unit-III: Concepts of Coding Block codes, Hamming distance, Maximum likelihood decoding, Levels of error handling, Error correction, Error detection, Erasure correction, Construction of finite fields, Linear codes, Matrix representation of linear codes, Hamming codes.	18
Unit-IV: Bounds of Codes Orthogonality relation, Encoding and decoding of linear codes, The singleton bound and maximum distance separable codes, The sphere-packing bound and perfect codes, The Gilbert-Varshamov bound, MacWilliams' identities.	18
Unit-V: Cyclic Codes Definition and examples of cyclic codes, Generator polynomial and check polynomial, Generator matrix and check matrix, Bose-Chaudhuri-Hocquenghem (BCH) code as a cyclic code.	18

References:

1. Robert B. Ash, (2014). Information Theory. Dover Publications, **(Textbook).**
2. Thomas M. Cover & Joy A. Thomas (2013). Elements of Information Theory (2nd edition). Wiley India Pvt. Ltd, **(Textbook).**
3. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition), Cengage.
4. Fazlollah M. Reza, (2003). An Introduction to Information Theory. Dover Publications.
5. Ron M. Roth (2007). Introduction to Coding Theory. Cambridge University Press.
6. Claude E. Shannon & Warren Weaver (1969). The Mathematical Theory of Communication. The University of Illinios Press.

<table>
<tr><td colspan="2">Course No: 28</td><td colspan="4">Course Name: Graph Theory</td><td colspan="5">Course Code: SBSMAT 03 05 06 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2" colspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="3">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="10">The objective of the course is to introduce students with the fundamental concepts of graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="10">After going through this course the students will be able to
Appreciate the definition and basics of graphs along with types and their examples.
Understand the definition of a tree and learn its applications to fundamental circuits.
Know the applications of graph theory to network flows.
Understand the notion of planarity and coloring of a graph.
Relate the graph theory to the real-world problems.</td></tr>
<tr><td colspan="9">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="9">Unit-I: Paths, Circuits and Graph Isomorphisms
Definition and examples of a graph, Subgraph, Walks, Paths and circuits; Connected graphs, disconnected graphs and components of a graph; Euler and Hamiltonian graphs, Graph isomorphisms, Adjacency matrix and incidence matrix of a graph, Directed graphs and their elementary properties.</td><td colspan="2">18</td></tr>
<tr><td colspan="9">Unit-II: Trees and Fundamental Circuits
Definition and properties of trees, Rooted and binary trees, Cayley's theorem on a counting tree, Spanning tree, Fundamental circuits, Minimal spanning trees in a connected graph.</td><td colspan="2">18</td></tr>
<tr><td colspan="9">Unit-III: Cut-Sets and Cut-Vertices
Cut-set of a graph and its properties, Fundamental circuits and cut-sets, Cut-vertices, Connectivity and separability, Network flows, 1- isomorphism and 2- isomorphism.</td><td colspan="2">18</td></tr>
</table>

Unit-IV: Planar Graphs Planar graph, Euler theorem for a planar graph, Various representations of a planar graph, Dual of a planar graph, Detection of planarity, Kuratowski's theorem.	18
Unit-V: Graph Coloring Chromatic number of a graph, Chromatic partition, Chromatic polynomial, Matching and coverings, Four color problem.	18

References:

1. R. Balakrishnan & K. Ranganathan (2012). A Textbook of Graph Theory. Springer, **(Textbook).**
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson, **(Textbook).**
3. Narsingh Deo (2016). Graph Theory with Applications to Engineering and Computer Science. Dover Publications.
4. Reinhard Diestel (2017). Graph Theory (5th edition). Springer.
5. Douglas West (2017). Introduction to Graph Theory (2nd edition). Pearson.

<table>
<tr><td colspan="1">Course No: 29</td><td colspan="2">Course Name:
Special Theory of Relativity</td><td colspan="6">Course Code: SBSMAT 03 05 07 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course provides a comprehensive introduction to the general theory of relativity where all forms of gravity can be described as a purely geometric effect where the curvature of space and time follows the distribution of energy and the amount momentum the matter has. An overview is given of the classical tests of theory, and how the theory is used to describe black holes, gravitational waves, and the cosmological evolution of the universe. The course also provides an introduction to differential geometry, which is necessary to be able to both formulate and apply the theory.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the basic elements of Newtonian mechanics including Michelson-Morley experiment and geometrical interpretations of Lorentz transformation equations.
Learn about length contraction, time dilation and Lorentz contraction factor.
Study 4-dimensional Minkowskian space-time and its consequences.
Understand equations of motion as a part of relativistic mechanics.
Imbibe connections between relativistic mechanics and electromagnetism.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Newtonian Mechanics
Inertial frames, Speed of light and Gallilean relativity, Michelson-Morley experiment, Lorentz-Fitzgerold contraction hypothesis, Relative character of space and time, Postulates of special theory of relativity, Lorentz transformation equations and its geometrical interpretation, Group properties of Lorentz transformations.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Relativistic Kinematics</td><td>18</td></tr>
</table>

Composition of parallel velocities, Length contraction, Time dilation, Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor.	
Unit-III: Geometrical representation of space-time Four dimensional Minkowskian space-time of special relativity, Time-like, light-like and space-like intervals, Null cone, Proper time, World line of a particle, Four vectors and tensors in Minkowiskian space-time.	18
Unit-IV: Relativistic Mechanics Variation of mass with velocity. Equivalence of mass and energy. Transformation equations for mass momentum and energy. Energy-momentum four vector. Relativistic force and Transformation equations for its components. Relativistic equations of motion of a particle.	18
Unit-V: Electromagnetism Transformation equations for the densities of electric charge and current. Transformation equations for electric and magnetic field strengths. The Field of a Uniformly Moving Point charge. Forces and fields near a current carrying wire. Forces between moving charges. The invariance of Maxwell`s equations.	18

References:

1. James L. Anderson (1973). Principles of Relativity Physics. Academic Press, **(Textbook).**
2. Robert Resnick (2007). Introduction to Special Relativity. Wiley**, (Textbook).**
3. Peter Gabriel Bergmann (1976). Introduction to the Theory of Relativity. Dover Publications.
4. C. Moller (1972). The Theory of Relativity (2nd edition). Oxford University Press.
5. Wolfgang Rindler (1977). Essential Relativity: Special, General, and Cosmological. Springer-Verlag.
6. V. A. Ugarov (1979). Special Theory of Relativity. Mir Publishers, Moscow.

Course No: 30	**Course Name:** Analytical Geometry				**Course Code:** SBSMAT 03 05 08 DSE 5106		
Batch: 2021-2026	**Programme:** **Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The course provides a comprehensive introduction to the general theory of geometry where all forms of conics can be described as a purely geometric effect. An overview of syllabus is the basic knowledge and to finds basic ideas the tangent and normal at any point, chord of contact and poles of line for a conic. Particular emphasis has been laid on sphere, cone and cylinder.						
Course Outcomes:	After going through this course the students will be able to • Derive system of conics, confocal conics and polar equation of a conic. • Determine the tangent and normal at any point, chord of contact and poles of line for a conic. • Understand the concept of sphere, cone and cylinder. • Obtain the equations of tangent plane, director sphere, normal to the conicoids and enveloping. • Describe circular section, plane sections of conicoids, generating lines, confocal conicoid and reductions of second degree equations.						

Content of Each Unit	**Hours of Each Unit**
Unit-I: The Plane System of Co-ordinates, Direction Cosines and Projection, Plane, Normal and Intercept form of the equation of the plane, Equation of some particular plane, pair of plane, Projection of a plane, area of a triangle whose co-ordinates in plane.	18
Unit-II: Conics Sections General equation of second degree. Tracing of conics. Tangent at any point to the conic,	18

chord of contact, pole of line to the conic, director circle of conic. System of conics. Confocal conics. Polar equation of a conic, tangent and normal to the conic.	
Unit-III: Sphere, Cones and Cylinder Sphere: Plane section of a sphere. Sphere through a given circle. Intersection of two spheres, radical plane of two spheres. Co-axal system of spheres.Cones. Right circular cone, enveloping cone and reciprocal cone. Cylinder: Right circular cylinder and enveloping cylinder.	18
Unit-IV: The conicoids Central Conicoids: Equation of tangent plane. Director sphere. Normal to the conicoids. Polar plane of a point. Enveloping cone of a coincoid. Enveloping cylinder of a coincoid.	18
Unit-V: Generalized conicoids Paraboloids: Circular section, Plane sections of conicoids. Generating lines. Reduction of second degree equations.	18

References:

1. R.J.T. Bill, Elementary Treatise on Coordinary Geometry of Three Dimensions, MacMillan India Ltd. 2018, **(Textbook).**
2. P.K. Jain and Khalil Ahmad, A Textbook of Analytical Geometry of Three Dimensions, Wiley Eastern Ltd. 2009, **(Textbook).**
3. Shantinarayan, Analytic Solid Geometry, 2020.
4. C. A. Hart and D. D. Feldman, Plane and Solid Geometry, 2019.
5. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
6. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) Pvt. Ltd.2002.
7. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.

SEMESTER – VI

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 06 01 C 5106	Complex Analysis	6	105	45	-	150
SBSMAT 03 06 02 C 4046	Numerical Analysis	4	70	30	-	100
SBSMAT 03 06 02 C 4046	Numerical Analysis (Lab)	4			50	50
DSE3		6	105	45	-	150
DSE4		6	105	45	-	150
Total marks of Semester-VI						600

Course No: 31	Course Name: Complex Analysis						Course Code: SBSMAT 03 06 01 C 5106
Batch: 2021-26	**Program:** **Integrated BSc-MSc (Mathematics)**	**Sem:** VI	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	To providing the basic knowledge and to finds basic ideas of analysis for complex functions in complex variables with visualization through relevant practical's. Particular emphasis has been laid on Cauchy's theorems and series expansions.						
Course Outcomes	After going through this course the students will be able to • Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere. • Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations. • Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals. • Apply Liouville's theorem in fundamental theorem of algebra. • Understand the convergence, term by term integration and differentiation of a power series.						

Content of Each Unit	Hours
Unit-I: Complex Plane and functions. Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.	18
Unit-II: Analytic Functions and Cauchy-Riemann Equations Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.	18

Unit-III: Cauchy's Theorems and Fundamental Theorem of Algebra Line integral, Path independence, Complex integration, Green's theorem, Anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula, Cauchy's inequality, Derivative of analytic function, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem and its consequences.	18
Unit-IV: Power Series Sequences, series and their convergence, Taylor series and Laurent series of analytic functions, Power series, Radius of convergence, Integration and differentiation of power series, Absolute and uniform convergence of power series.	18
Unit-V: Singularities and Contour Integration Meromorphic functions, Zeros and poles of meromorphic functions, Nature of singularities, Picard's theorem, Residues, Cauchy's residue theorem, Argument principle, Rouche's theor- em, Jordan's lemma, Evaluation of proper and improper integrals.	18

References:

1. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (9th edition). McGraw-Hill Education, **(Textbook).**
2. John B. Conway (1973). Functions of One Complex Variable. Springer-Verlag, **(Textbook).**
3. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
4. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
5. E.T. Copson (1970). Introduction to Theory of Functions of Complex Variable. Oxford University Press.
6. Theodore W. Gamelin (2001). Complex Analysis. Springer-Verlag.
7. George Polya & Gordon Latta (1974). Complex Variables. Wiley.
8. H. A. Priestley (2003). Introduction to Complex Analysis. Oxford University Press.
9. E. C. Titchmarsh (1976). Theory of Functions (2nd edition). Oxford University Press.

<table>
<tr><td>Course No: 32</td><td colspan="3">Course Name: Numerical Analysis</td><td colspan="5">Course Code: SBSMAT 03 06 02 C 4046</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem:VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td colspan="2">Total Hours: 120</td></tr>
<tr><td>Course Objective</td><td colspan="8">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Obtain numerical solutions of algebraic and transcendental equations.
Find numerical solutions of system of linear equations and check the accuracy of the solutions.
Learn about various interpolating and extrapolating methods.
Solve initial and boundary value problems in differential equations using numerical methods.
Apply various numerical methods in real life problems.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Numerical Methods for Solving Algebraic and Transcendental Equations
Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.</td><td>24</td></tr>
<tr><td colspan="8">Unit-II: Numerical Methods for Solving Linear Systems
Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a</td><td>24</td></tr>
</table>

matrix and its applications, Thomas method for tridiagonal systems; Gauss-Jacobi, Gauss-Seidel and successive over-relaxation (SOR) methods.	
Unit-III: Interpolation Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory-Newton forward and backward difference interpolations.	24
Unit-IV: Numerical Differentiation and Integration First order and higher order approximation for first derivative, Approximation for second derivative; Numerical integration: Trapezoidal rule, Simpson's rules and error analysis, Bulirsch-Stoer extrapolation methods, Richardson extrapolation.	24
Unit-V: Initial and Boundary Value Problems of Differential Equations Euler's method, Runge-Kutta methods, Higher order one step method, Multi-step methods; Finite difference method, Shooting method, Real life examples: Google search engine, 1D simulations, Weather forecasting.	24

References:

1. R. K. Gupta, Numerical methods: Fundamental and Applications, 1st Edition, Cambridge University Press, **(Textbook).**
2. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers, **(Textbook).**
3. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
4. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.
5. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.
6. Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

<table>
<tr><td>Course No: 33</td><td colspan="3">Course Name: Discrete Mathematics</td><td colspan="5">Course Code: SBSMAT 03 06 01 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations, trees and graphs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Learn about partially ordered sets, lattices and their types.
• Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.
• Solve real-life problems using finite-state and Turing machines.
• Assimilate various graph theoretic concepts and familiarize with their applications.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Partially Ordered Sets
Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Lattices
Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.</td><td>18</td></tr>
</table>

Unit-III: Boolean Algebras and Switching Circuits Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive and conjunctive normal forms, Minimal forms of Boolean polynomials, Quine-McCluskey method, Karnaugh diagrams, Switching circuits and applications.	18
Unit-IV: Finite-State and Turing Machines Finite-state machines with outputs, and with no output; Deterministic and nodeterministic finite-state automaton; Turing machines: Definition, examples, and computations.	18
Unit-V: Basic of Graphs Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling- salesman problem, Shortest path and Dijkstra's algorithm.	18

References:

1. Kenneth H. Rosen (2012). Discrete Mathematics and its Applications: With Combinatorics and Graph Theory (7th edition). McGraw-Hill, **(Textbook).**
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education, **(Textbook).**
3. B. A. Davey & H. A. Priestley (2002). Introduction to Lattices and Order (2nd edition). Cambridge University Press.
4. Rudolf Lidl & Günter Pilz (1998). Applied Abstract Algebra (2nd edition). Springer.
5. C. L. Liu (1985). Elements of Discrete Mathematics (2nd edition). McGraw-Hill.

<table>
<tr><td>Course No: 34</td><td colspan="4">Course Name: Wavelets and Applications</td><td colspan="4">Course Code: SBSMAT 03 06 02 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">Most students today have had experience downloading compressed image or sound files from the web, or using software such as Adobe Photoshop to enhance a photo they have taken, or watching a crime solving drama where the fingerprints of a perpetrator are compared against those stored in AFIS. This course uses mathematical theory, recently developed applications, and computation to introduce students to the basics of the enhancement and compression of digital image and sound files. Students from mathematics, physics, and computer science might benefit from such a course.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Know basic concepts of signals and systems.
• Understand the concept of Haar spaces.
• Learn Fourier transform and wavelet transform of digital signals.
• Learn applications of wavelets to the real-world problems.
• Apply wavelets in signal processing and image processing.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I: Signals and Systems
Basic concepts of signals and systems, Frequency spectrum of signals; Classification of signals: Discrete time signals and continuous time signals, periodic and non-periodic signals; Classification of systems: Linear, nonlinear, time-variant, time-invariant, stable and unstable systems.</td><td colspan="2">18</td></tr>
<tr><td colspan="7">Unit-II: Haar Scaling Function and Wavelet, Time-Frequency Analysis
Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions,</td><td colspan="2">18</td></tr>
</table>

Haar scaling function, Haar spaces: Haar space VO, general Haar space Vj; Haar wavelet, Haar wavelet spaces: Haar wavelet space WO, general Haar wavelet space Wj; Decomposition and reconstruction, Time-frequency analysis, Orthogonal and orthonormal bases.	
Unit–III: Fourier Transforms and Wavelets Discrete Fourier transform of a digital signal, Complex form of a Fourier series, Inverse discrete Fourier transform, Window Fourier transform, Short time Fourier transform, Admissibility condition for a wavelet, Classes of wavelets: Haar, Morlet, Maxican hat, Meyer and Daubechies wavelets; Wavelets with compact support.	18
Unit–IV: Discrete Wavelet Transforms Stationary and non-stationary signals, Haar transform, 1-level Haar transform, Multi-level Haar transform, Conservation and compaction of energy, Multiresolution analysis, Decomposition and reconstruction of signals using discrete wavelet transform (DWT).	18
Unit–V: Applications Wavelet series expansion using Haar and other wavelets, Applications in signal compression, Analysis and classification of audio signals using DWT, Signal de-noising: Image and ECG signals.	18

References:

1. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press, **(Textbook).**
2. David K. Ruch & Patrick J. Van Fleet (2009), Wavelet Theory: An Elementary Approach with Applications. John Wiley & Sons, **(Textbook).**
3. Ingrid Daubechies (1999). Ten Lectures on Wavelets. SIAM
4. Michael W. Frazier (1999). An Introduction to Wavelets Through Linear Algebra. Springer-Verlag.
5. Stéphane Mallat (2008). A Wavelet Tour of Signal Processing (3rd edition). Academic Press.
6. M.J. Roberts (2004). Signals and Systems: Analysis Using Transform Methods and MATLAB. McGraw-Hill Education.
7. James S. Walker (2008). A Primer on Wavelets and Their Scientific Applications (2nd edition). Chapman & Hall/CRC, Taylor & Francis.

<table>
<tr><td>Course No: 35</td><td colspan="3">Course Name: Number Theory</td><td colspan="5">Course Code: SBSMAT 03 06 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is aimed at undergraduate mathematics majors. It is a first course in number theory, and is intended to introduce students to number theoretic problems and to different areas of number theory. Number theory has a very long history compared to some other areas of mathematics, and has many applications, especially to coding theory and cryptography.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Wilson's theorem and their consequences.
• Learn about number theoretic functions, modular arithmetic and their applications.
• Familiarize with modular arithmetic and find primitive roots of prime and composite numbers.
• Know about open problems in number theory, namely, the Goldbach conjecture and twin-prime conjecture.
• Apply public crypto systems, in particular, RSA.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Distribution of Primes and Theory of Congruencies
Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Twin-prime conjecture, Odd perfect numbers conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.</td><td>18</td></tr>
</table>

Unit-II: Number Theoretic Functions Number theoretic functions for sum and number of divisors, Multiplicative function, The Möbius inversion formula, Greatest integer function, Euler's phi-function and properties, Euler's theorem.	18
Unit-III: Primitive Roots Order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, Euler's criterion.	18
Unit-IV: Quadratic Reciprocity Law The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli.	18
Unit-V: Applications Public key encryption, RSA encryption and decryption with applications in security systems.	18

References:

1. David M. Burton (2007). Elementary Number Theory (7th edition). McGraw-Hill, **(Textbook).**
2. Neville Robbins (2007). Beginning Number Theory (2nd edition). Narosa, **(Textbook).**
3. Gareth A. Jones & J. Mary Jones (2005). Elementary Number Theory. Springer.
4. I.Niven (2012). An Introduction to the Theory of Numbers (5th edition). John Wiley & Sons.
5. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag.

<table>
<tr><td>Course No: 36</td><td colspan="2">Course Name: Mathematical Finance</td><td colspan="5">Course Code: SBSMAT 03 06 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course provides an introduction to the basic mathematical concepts and techniques used in finance and business, highlighting the inter-relationships of the mathematics and developing problem solving skills with a particular emphasis on financial and business applications..</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand financial markets and derivatives including options and futures.
Appreciate pricing and hedging of options, interest rate swaps and no-arbitrage pricing concepts.
Learn stochastic analysis, Ito’s formula, Ito integral and the Black−Scholes model.
Study and use Hedging parameters, trading strategies and currency swaps.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Basic Theory of Interest and Fixed-Income Securities
Principal and interest: simple, compound and continuous; Present and future value of cash flow streams; Net present value, Internal rates of return and their comparison; Inflation, Annuities; Bonds, Bond prices and yields, Macaulay duration and modified duration.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Term Structure of Interest Rates, Bonds and Derivatives
Spot rates, forward rates and explanations of term structure; Running present value, Floating- rate bonds, Immunization, Convexity; Putable and callable bonds; Exchange-traded markets and over-the-counter markets; Derivatives: Forward contracts, Future contracts, Options, Types of traders, Hedging, Speculation, Arbitrage.</td><td>18</td></tr>
</table>

Unit-III: Mechanics of Options Markets No-arbitrage principle, Short selling, Forward price for an investment asset; Types of options: Call and put options, Option positions, Underlying assets, Factors affecting option prices, Upper and lower bounds for option prices, Put-call parity, Effect of dividends.	18
Unit-IV: Stochastic Analysis of Stock Prices and Black-Scholes Model Binomial option pricing model, Risk neutral valuation: European and American options on assets following binomial tree model; Lognormal property of stock prices, Distribution of rate of return, Expected return, Volatility, Estimating volatility from historical data, Extension of risk-neutral valuation to assets following geometric Brownian motion, Black-Scholes formula for European options.	18
Unit-V: Hedging Parameters, Trading Strategies and Swaps Hedging parameters: Delta, gamma, theta, rho and vega; Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swaps, Currency swaps, Valuation of currency swaps.	18

References:

1. John C. Hull & Sankarshan Basu (2018). Options, Futures and Other Derivatives (10th edition). Pearson Education, **(Textbook).**
2. David G. Luenberger (2013). Investment Science (2nd edition). Oxford University Press.
3. Sheldon M. Ross (2011). An Elementary Introduction to Mathematical Finance (3rd edition). Cambridge University Press.

<table>
<tr><td>Course No: 37</td><td colspan="3">Course Name: Cryptography</td><td colspan="5">Course Code: SBSMAT 03 06 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">Cryptography is the practice and study of techniques for securing communications in the presence of third parties. This course aims to impart knowledge and protect information in order to ensure its integrity, confidentiality, authenticity, and non-repudiation. This course gives with a basic understanding of cryptographic concepts and how to apply them, implement secure protocols, key management concepts, key administration and validation, and Public Key Infrastructure.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the difference between classical and modern cryptography.
Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards (DES & AES) and RSA.
Encrypt and decrypt messages using block ciphers, sign and verify messages using well-known signature generation and verification algorithms.
Know about the aspects of number theory which are relevant to cryptography.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit I: Introduction to Cryptography and Classical Cryptography
Cryptosystems and basic cryptographic tools: Secret-key cryptosystems, Public-key cryptosystems, Block and stream ciphers, Hybrid cryptography, Message integrity: Message authentication codes, Signature schemes, Nonrepudiation, Certificates, Hash functions, Cryptographic protocols, Security; Hybrid cryptography: Message integrity, Cryptographic protocols, Security, Some simple cryptosystems, Shift cipher, Substitution cipher, Affine cipher, Vigenère cipher, Hill cipher, Permutation cipher, Stream ciphers, Cryptanalysis of affine, substitution, Vigenère, Hill and LFSR stream ciphers.</td><td>18</td></tr>
</table>

Unit-II: Cryptographic Security, Pseudo Randomness and Symmetric Key Ciphers Shannon's theory, Perfect secrecy, Entropy, Spurious keys and unicity distance; Bit generators, Security of pseudorandom bit generators. Substitution-permutation networks, Data encryption standard (DES), Description and analysis of DES; Advanced encryption standard (AES), Description and analysis of AES; Stream ciphers, Trivium.	18
Unit-III: Basics of Number Theory and Public-Key Cryptography Basics of number theory; Introduction to public-key cryptography, RSA cryptosystem, Implementing RSA; Primality testing, Legendre and Jacobi symbols, Solovay-Strassen algorithm, Miller-Rabin algorithm; Square roots modulo n, Factoring algorithms, Pollard P - 1 algorithm, Pollard rho algorithm, Dixon's random squares algorithm, Factoring algorithms in practice; Rabin cryptosystem and its security.	18
Unit-IV: More on Public-Key Cryptography Basics of finite fields; ElGamal cryptosystem, Algorithms for the discrete logarithm problem, Shanks' algorithm, Pollard rho discrete logarithm algorithm, Pohlig-Hellman algorithm; Discrete logarithm algorithms in practice, Security of ElGamal systems, Bit security of discrete logarithms.	18
Unit-V: Hash Functions and Signature Schemes Hash functions and data integrity, SHA-3; RSA signature scheme, Security requirements for signature schemes, Signatures and Hash functions, ElGamal signature scheme, Security of ElGamal signature scheme, Certificates.	18

References:

1. Jeffrey Hoffstein, Jill Pipher & Joseph H. Silverman (2014). An Introduction to Mathematical Cryptography (2nd edition). Springer, **(Textbook).**
2. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag, **(Textbook).**
3. Christof Paar & Jan Pelzl (2014). Understanding Cryptography. Springer.
4. Simon Rubinstein-Salzedo (2018). Cryptography. Springer.
5. Douglas R. Stinson & Maura B. Paterson (2019). Cryptography Theory and Practice (4th edition). Chapman & Hall/CRC Press, Taylor & Francis.

<table>
<tr><td>Course No: 38</td><td colspan="3">Course Name: Advanced Mechanics</td><td colspan="5">Course Code: SBSMAT 03 06 06 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">In this course, students will be imparted knowledge to enable them to understand several concepts of Advanced Mechanics such as Central axis, Wrench, Impulsive motion, Streamlines, pathlines, Moments and products of inertia.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to

Understand the reduction of force system in three dimensions to a resultant force acting at a base point and a resultant couple, which is independent of the choice of base of reduction.
Learn about a null point, a null line, and a null plane with respect to a system of forces acting on a rigid body together with the idea of central axis.
Know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia and to derive Euler's equations of motion of a rigid body, moving about a point which is kept fixed.
Study the kinematics and kinetics of fluid motions to understand the equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates which are used to derive Euler's equations and Bernoulli's equation.
Deal with two-dimensional fluid motion using the complex potential and also to understand the concepts of sources, sinks, doublets and the image systems of these with regard to a line and a circle.
</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Statics in Space
Forces in three dimensions, Reduction to a force and a couple, Equilibrium of a system of particles, Central axis and Wrench, Equation of the central axis, Resultant wrench of two wrenches; Null points, lines and planes with respect to a system of forces, Conjugate forces and conjugate lines.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Motion of a Rigid Body</td><td>18</td></tr>
</table>

Moments and products of inertia of some standard bodies, Momental ellipsoid, Principal axes and moments of inertia; Motion of a rigid body with a fixed point, Kinetic energy of a rigid body with a fixed point and angular momentum of a rigid body, Euler's equations of motion for a rigid body with a fixed point, Velocity and acceleration of a moving particle in cylindrical and spherical polar coordinates, Motion about a fixed axis, Compound pendulum.	
Unit-III: Kinematics of Fluid Motion Lagrangian and Eulerian approaches, Material and convective derivatives, Velocity of a fluid at a point, Equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates, Cylindrical and spherical symmetry, Boundary surface, Streamlines and pathlines, Steady and unsteady flows, Velocity potential, Rotational and irrotational motion, Vorticity vector and vortex lines.	18
Unit-IV: Kinetics of Fluid Motion Euler's equations of motion in Cartesian, cylindrical polar and spherical polar coordinates; Bernoulli's equation, Impulsive motion.	18
Unit-V: Motion in Two-Dimensions Stream function, Complex potential, Basic singularities: Sources, sinks, doublets, complex potential due to these basic singularities; Image system of a simple source and a simple doublet with regard to a line and a circle, Milne-Thomson circle theorem.	18

References:

1. A. S. Ramsay (1960). A Treatise on Hydromechanics, Part-II Hydrodynamics. G. Bell & Sons, **(Textbook).**
2. F. Chorlton (1967). A Textbook of Fluid Dynamics. CBS Publishers, **(Textbook).**
3. Michel Rieutord (2015). Fluid Dynamics An Introduction. Springer.
4. E. A. Milne (1965). Vectorial Mechanics, Methuen & Co.Limited. London.

<table>
<tr><td>Course No: 39</td><td colspan="4">Course Name: Dissertation on Any Topic of Mathematics</td><td colspan="3">Course Code: SBSMAT 03 06 07 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem:VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
</table>

9. GENERIC ELECTIVE COURSES (GEC)

(Only for Other Departments)

Sr.	Course code	Course title	L	T	P	Credits
1.	SBSMAT 03 01 01 GE 4046	Object Oriented Programming in C++(P)	4	0	4	6
2.	SBSMAT 03 01 02 GE 5106	Finite Element Methods	5	1	0	6
3.	SBSMAT 03 01 03 GE5106	Algebra	5	1	0	6
4.	SBSMAT 03 02 01 GE 5106	Econometrics	5	1	0	6
5.	SBSMAT 03 02 02 GE 5106	Mathematical Finance	5	1	0	6
6.	SBSMAT 03 02 03 GE 5106	Real Analysis	5	1	0	6
7.	SBSMAT 03 03 01 GE 5106	Introductory Calculus and Analysis	5	1	0	6
8.	SBSMAT 03 03 02 GE 5106	Basic Mathematics for Social Sciences	5	1	0	6
9.	SBSMAT 03 03 03 GE 5106	Probability and Statistics	5	1	0	6
10.	SBSMAT 03 04 01 GE 5106	Vector Calculus	5	1	0	6
11.	SBSMAT 03 04 02 GE 5106	Mathematics for Chemists	5	1	0	6
12.	SBSMAT 03 04 03 GE 5106	Numerical Methods	5	1	0	6

Note: Any course from MOOCs for PG students on SWAYAM can also be taken as DSEC or GEC course on recommendations of the department.

<table>
<tr><td>Course No: 01</td><td colspan="3">Course Name: Object Oriented Programming in C++</td><td colspan="5">Course Code: SBSMAT 03 01 01 GE 4046</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Programme: UG

Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td colspan="2">Total Hours: 120</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:

TEE:</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="8">The main objective of this course is to define and highlight the importance of object oriented programming. The students will see how to use concepts of object oriented programming in real-life using C++ programming language. The students will learn potential C++ features like overloading, type conversions, inheritance.</td></tr>
<tr><td></td><td colspan="8">After going through this course the students will be able to
Write C-programmes to solve Mathematical problems.
Design algorithms to solve problems.
Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism.
Emphasize on the importance of use of Friend Functions for efficient C++ programming.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="7">OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-</td><td>30</td></tr>
</table>

	based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.	
II	Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables withFunctions.	30
III	Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers – private, publicand protected. Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members.	30
IV	Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator, concepts of namespaces.	30

Books Recommended:

1. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997, **(Textbook).**
2. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
3. Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall.Parasons, Object Oriented Programming with C++, BPB Publication.
4. B. Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley.

<table>
<tr><td>Course No: 2</td><td colspan="4">Course Name: Finite Element Methods</td><td colspan="3">Course Code: SBSMAT 03 01 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:

2021-2026</td><td rowspan="2">Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course includes an introduction about different finite element methods in one- two and three-dimensions. The course focuses on analyzing variety of finite elements as per the requirements of solutions of differential equations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
Describe finite element methods
Differential equations using finite element methods
Emphasize on the importance of use of Simplex elements in two and three dimensions.
Understand the Interpolation functions, numerical integration and modeling considerations.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method. Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.</td><td>23</td></tr>
</table>

II	Applications to solving simple problems of ordinary differential equations. Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.	22
III	Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries.	23
IV	Interpolation functions, numerical integration, and modeling considerations**.** Solution of two dimensional partial differential equations under different Geometric conditions.	22

Books Recommended:

1. J.N. Reddy, Introduction to the Finite Element Methods, Tata McGraw-Hill, 2003, **(Textbook).**

2. K.J. Bathe, Finite Element Procedures, Prentice-Hall, 2001**.**

3. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, John Wiley and Sons, 2002.

4. T. J.R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publication, 2000**.**

5. G. R. Buchanan, Finite Element Analysis, McGraw Hill, 1994.

<table>
<tr><td>Course No: 3</td><td colspan="3">Course Name: Algebra</td><td colspan="5">Course Code: SBSMAT 03 01 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td>Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td></td><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: N.A.</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After going through this course the students will be able to
• Work with the trigonometric form of complex numbers including De-Moivre’s formula.
• Be familiar with the Euler form $re^{i\Theta}$ of complex numbers
• Apply the elementary operations on the matrices. Compute the eigen values, eigen function, characteristic equation and minimal polynomial of a given matrix.
• Obtain the solution of the systems of linear equations using the concept of rank of matrices</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
</table>

I	Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set.	23
II	Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.	23
III	Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence	22
IV	Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, Characterizations of invertible matrices. Subspaces of $\mathbf{R}^n$, dimension of subspaces $\mathbf{R}^n$ and rank of a matrix, Eigenvalues, Eigen Vectors and Characteristic Equation of a matrix.	22

Books Recommended:

1. Hall & Night, Higher Algebra, Arihant Publishers, 2013, **(Textbook).**
2. K. Hoffman, R.A. Kunze, Linerar Algebra 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.
3. S. L. Loney, Plane Trigonometry, Arihant Publishers, 2016.
4. D. C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint,2007, **(Textbook).**
5. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis. Willy Std Edition, 2014.
6. B Das & B N Mukherjee, Higher Trigonometry, U N Dhur & Sons, 2007.
7. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhauser,2006.
8. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

<table>
<tr><td>Course No: 4</td><td colspan="5">Course Name: Econometrics</td><td colspan="3">Course Code: SBSMAT 03 02 01 GE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-2026</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td colspan="2">P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td colspan="2">0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE:
TEE:</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="8">Econometrics is a set of research tools used to estimate and test economic relationships. The methods taught in this introductory course can also be employed in the business disciplines of accounting, finance, marketing and management and in many social science disciplines. The aim of this course is to provide you with the skills helpful in filling the gap between being “a student of economics” and being “a practicing economist.”</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students should be able to
Design models and solve problems related to Economic issues.
Describe the Statistical Concepts
Understand the Detection, Remedies and Multicollinearity.
Be familiars with the Type I and Type II errors.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="7">Statistical Concepts Normal distribution; chi-square, t and F-</td><td>22</td></tr>
</table>

	distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.	
II	Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.	23
III	Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R2 and adjusted R2 ; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables.	23
IV	Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation. Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.	22

Books Recommended:

1. J. L. Devore, Probability and Statistics for Engineers, Cengage Learning,2010, **(Textbook).**
2. J. E. Freund, Mathematical Statistics, Prentice Hall,1992.
3. R. J. Larsen and Morris L. Marx, An Introduction to Mathematical Statistics and its Applications, Prentice Hall,2011.
4. D. N. Gujarati and D.C. Porter, Essentials of Econometrics, McGraw Hill, 4th Ed., International Edition,2009, **(Textbook).**
5. C. Dougherty, Introduction to Econometrics, Oxford University Press, 3rd Ed., Indian edition,2007.

<table>
<tr><td>Course No: 5</td><td colspan="5">Course Name: Mathematical Finance</td><td colspan="3">Course Code: SBSMAT 03 02 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:

2021-2026</td><td rowspan="2">Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td colspan="2">Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td colspan="2">6</td><td>Total Hours: 90</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course introduces the basic concepts of Financial Management such as Insurance and Measurement of returns under uncertainty situations. The philosophy of this course is that Time value of Money - Interest rate and discount rate play a fundamental role in Life Insurance Mathematics – Construction of Morality Tables.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After going through this course the students will be able to
Build quantitative models of financial mathematics/industries
Apply models to obtain information of practical value in the financial mathematics
Understand the terms random returns, portfolio mean return and variance.
Design models and solve problems related to financial issues</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="7">Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by</td><td>20</td></tr>
</table>

	bisection and Newton-Raphson methods), comparison of NPV and IRR.	
II	Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds.	24
III	Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index.	23
IV	Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.	23

Books Recommended:

1. D. G. Luenberger, Investment Science, Oxford University Press, Delhi,1998.
2. J. C. Hull, Options, Futures and Other Derivatives, 6th Ed., Prentice-Hall India, Indian reprint,2006, **(Textbook).**
3. S. Ross, An Elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA,2003.

<table>
<tr><td>Course No: 06</td><td colspan="5">Course Name: Real Analysis</td><td colspan="3">Course Code: SBSMAT 03 02 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:

2021-2026</td><td rowspan="2">Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighborhood of a point, countable sets , sequence and series, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After going through this course the students will be able to
• Identify the properties of the number system and Describe various analytical properties of the real number system.
• Explain the concept of sequences and their types and Identify the convergence of sequences and series of positive terms.
• Apply various important convergence tests to the given series.
• Understand the difference between conditional and absolute convergence of alternating series.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

I	Review of Algebraic and Order Properties of *R*, neighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property.	23
II	Density of Rational (and Irrational) numbers in *R*, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets. Sequences, Bounded sequence, Convergent sequence, Limit of a sequence.	23
III	Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.	22
IV	Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Test for Convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.	22

Books Recommended:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002, **(Textbook).**
2. I. Kumar and S. Kumarasen, A Basic Course in Real Analysis, CRC Press, 2014, **(Textbook).**
3. G. B. Thomas and R. L. Finney, Calculus, Pearson, 9th Ed, 2005.
4. G. G. Bilodeau , P. R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett,2010.
5. S. Thomson, A. M. Bruckner and J. B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
6. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.

<table>
<tr><td>Course No:
07</td><td colspan="3">Course Name:
Introductory Calculus and Analysis</td><td colspan="5">Course Code: SBSMAT 03 03 01 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce basic structures of mathematics like limit, continuity, differentiability integration, sequence, and series. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
Calculate the limit and examine the continuity of a function at a point.
Understand the consequences of various mean value theorems for differentiable functions.
Understand the integration and their applications.</td></tr>
</table>

Content of Each Unit	**Hours**
Unit I: Successive differentiation and Leibnitz theorem, limits, continuity, and differentiability, Mean value theorem, Taylors Theorem, Maxima and Minima.	18
Unit-II: Riemann integration, Darboux theorem, Fundamental theorem of integral Calculus, Improper integrals, Beta function, Gamma functions and related definite integrals. Surface area and Volume.	18
Unit-III: Convergence of sequences and series, power series.	18
Unit-IV: Partial differentiation, Euler’s theorem and chain rule. Directional derivatives and gradients, maxima and minima, Lagrange multipliers.	18
Unit-V: Double and Triple integration, Jacobians and change of variables. Parametrization of curves and surfaces, vector Fields, line and surface integrals. Divergence and curl, Theorems of Green, Gauss, and Stokes.	18

References:

1. M. D. Weir, J. Hass and F. R. Giordano: *Thomas' Calculus*, 11th edition, Pearson, 2008 **(Textbook).**
2. T. M. Apostol: *Calculus, Volumes 1 and 2*, 2nd edition, Wiley, 1980.
3. J. Stewart: *Calculus*, 5th edition, Thomson, 2003.
4. N. Piskunov: Differential and Integral Calculus, Mir Publishers, 1969.
5. S. Narayan: A Textbook of Vector Calculus, S. Chand, 2003.

<table>
<tr><td>Course No: 08</td><td colspan="2">Course Name: Basic Mathematics for Social Sciences</td><td colspan="5">Course Code: SBSMAT 03 03 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of this course is to encourage students to develop a working knowledge of the basic Mathematics for social science and will present some of the ideas that form the foundation of quantitative work in the social sciences. In particular, topics from logarithm, set theory, matrix theory and calculus will be discussed with emphasis on the understanding ofconcepts and the development of intuition.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Explain the fundamental concepts of indices, logarithm and antilogarithm and their role in basic Mathematics for social science.
Demonstrate accurate and efficient use of set theory and Venn diagram.
Understand and use the terms: function, relation, series arithmetic, geometric progression, Permutations and Combinations.
Understand the concepts and properties of limits, continuity and differentiation of a function, logical reasoning, probability and descriptive statistics</td></tr>
</table>

Content of Each Unit	**Hours**
Unit-I Binary numbers, indices, logarithm and antilogarithm, laws and properties of logarithms, simple applications of logarithm and antilogarithm, numerical problems on averages, calendar, clock, time, work and distance, mensuration, seating arrangement, sets, types of sets, Venn diagram, De Morgan's laws, problem solving using Venn diagram, relations and types of relations.	18
Unit-II Introduction of sequences, series arithmetic and geometric progression, relationship between AM and GM. Basic concepts of permutations and combinations, permutations, combinations with standard results. Introducing functions, domain and range of a function, types of functions (Polynomial function; Rational function; Logarithm function, Exponential function; Modulus function; Greatest Integer function, Signum function), Graphical representation of functions.	18

Unit-III Concept of limits and continuity of a function, instantaneous rates of change, differentiation as a process of finding derivative, derivatives of algebraic functions using Chain rule. Mathematically acceptable statements, connecting words/ phrases in Mathematical statement consolidating the understanding of "if and only if (necessary and sufficient) condition", "implies", "and/or", "implied by", "and", "or", "there exists" and their use through variety of examples related to real life and Mathematics problems based on logical reasoning (coding-decoding, odd man out, blood, relation, syllogism etc).	18
Unit-IV Random experiment, sample space, events, mutually exclusive events. Independent and dependent Events, law of total probability, Bayes' Theorem.	18
Unit-V Data on various scales (nominal, ordinal, interval and ratio scale), data representation and visualization, data interpretation (dispersion, deviation, variance, skewness and kurtosis), percentile rank and quartile rank, correlation (Pearson and Spearman method of correlation), applications of descriptive statistics using real time data.	18

References:

1. Gill J. Essential Mathematics for Political and Social Research, Cambridge University Press, 2016 **(Textbook).**
2. Haeussler E., Paul R. and Wood R. Introductory Mathematical Analysis for Business, Economics, and the Life and Social Sciences, 15th edition. Prentice-Hall, 2015.
3. Goldstein L., Lay D., and Schneider D. Calculus and Its Applications, 14^{th} Edition. Prentice Hall, 2014.
4. Hagle T. Basic Math for Social Scientists: Problems and Solutions, 1996.
5. Hagle T. Basic Math for Social Scientists: Concepts, 1996.
6. Kleppner D. and Ramsey N. Quick Calculus. Wiley, 1995.

<table>
<tr><td>Course No: 09</td><td colspan="4">Course Name: Probability and Statistics</td><td colspan="5">Course Code: SBSMAT 03 03 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="3">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="9">To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses. After taking this course, students will be able to use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB, to perform simple and sophisticated analyses for large samples.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">After going through this course the students will be able to
• Understand distributions in the study of the joint behaviour of two random variables.
• Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
• Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.</td></tr>
<tr><td colspan="9">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="9">Unit-I: Probability Functions and Moment Generating Function
Basic notions of probability, Conditional probability and independence, Baye’s theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.</td><td>18</td></tr>
<tr><td colspan="9">Unit-II: Univariate Discrete and Continuous Distributions
Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.</td><td>18</td></tr>
<tr><td colspan="9">Unit-III: Bivariate Distribution
Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.</td><td>18</td></tr>
</table>

Unit-IV: Correlation, Regression and Central Limit Theorem The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.	18
Unit-V: Modeling Uncertainty Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.	18

References:

1. Irwin Miller & Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India, **(Textbook).**
2. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.
6. V.K. Kapoor and S. C. Gupta (2018). Fundamental of Mathematical Statistics, S. Chand & Sons.

<table>
<tr><td>Course No: 10</td><td colspan="3">Course Name: Vector Calculus</td><td colspan="4">Course Code: SBSMAT 03 04 01 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course provides an introduction to functions of several real variables and classical vector analysis. Topics discussed are: partial derivatives, gradients, line and surface integrals; vector valued functions, divergence, curl and flux of vector fields, the theorems of Green and Stokes, the divergence theorem, and applications</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Find the Triple product of Products and their Applications
Understand the concept of Line integral and Surface integral
Understand the concept of Tensor</td></tr>
</table>

Content of Each Unit	**Hours**
Unit I Vectors, Scalars and Dot Product, Triple Products, Scalar and Vector Fields, Methods of Integration and Examples,	18
Unit-II: Line Integrals, Surface and Volume Integrals with Examples, Partial Differentiation, Taylor Series and Gradients, Divergence, Laplacian and Curl	18
Unit-III: Suffix Notation, Kronecker Delta and Alternating Tensor and Review, Relations Among and Properties of Vector and Tensor Operations, Gauss' Divergence Theorem and Applications, Stokes' Theorem and Applications, More on Gauss' and Stokes' Theorems	18
Unit-IV: Curvilinear Coordinates, Gradient, Divergence and Curl in Curvilinear Coordinates, Examples in Cylindrical and Spherical Coordinates	18
Unit-V: Tensors and Applications and Review, Tensors and Applications, Physical Applications of Tensors, Applications	18

References:

1. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas Calculus, 13/e, Pearson Publishers, 2013, (**Textbook**).
2. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, 3/e, Alpha Science International Ltd., 2002.
3. Michael Greenberg, Advanced Engineering Mathematics, 2/e, Pearson, 2018.

Course No: 11	**Course Name:** Mathematics for Chemists			**Course Code:** SBSMAT 03 04 02 GE 5106			
Batch:	**Program: UG**	**Sem:** IV	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The main objective of this course is to introduce the students to the exciting world of numerical analysis, differential equations and statistics.						
Course Outcomes	After completing this course, student is expected to learn the following: • Learn the basics of numerical analysis, to calculate the errors in approximations and their properties. • Understand the basics of differential equations to solve the first order linear differential equations and second order differential equations. • Analyze the singular points, power series solution of differential equation at regular and irregular singular points, Bessel's and Legendre's equations and their solutions. • Use the basics tools of statistics and by using these techniques to measures central tendency, learn Gaussian and Binomial distributions.						

Content of Each Unit	Hours
Unit-I Algebraic, transcendental functions, approximation, errors in approximation, absolute, relative and percentage errors, matrices and their properties, some special matrices, matrix algebra, the inverse matrix, linear transformations, orthogonal matrices and orthogonal transformations.	15
Unit-II Solution of differential equations, first-order linear equations- separable equations, homogeneous linear equations, non-homogeneous linear equations, second-order differential equations with constant coefficients, general solution, particular solution, linear equations in chemical kinetics, harmonic oscillator and some other applications	15

Unit-III Singular points, power series solution of differential equation at regular and irregular singular points, Bessel's and Legendre's equations and their solutions, partial differentiation, types of partial differential equations.	15
Unit-IV Line integrals, double integrals, change of variables, polar coordinates, volume integrals, Laplacian operator, finite difference operators.	
Unit-V Descriptive statistics, measures of central tendency, measures of dispersion, frequency and probability, permutations and combinations, binomial distribution, Gaussian distribution.	15

References:

1. Steiner, E. The Chemistry Maths Book. 2nd edition, Oxford University Press, 2008, **(Textbook).**
2. Gupta, S. C. and Kapoor, V.K. Fundamentals of Mathematical Statistics. S. Chand & Sons, 2014.
3. Lipschutz, S. and Lipson, M. Linear Algebra. 3rd edition, Tata McGraw-Hill, 2005.
4. Raisinghania, M. D. Advanced Differential Equations. S. Chand & Company Ltd. New Delhi, 2001.

<table>
<tr><td colspan="3">Course No: 12</td><td colspan="3">Course Name: Numerical Methods</td><td colspan="3">Course Code: SBSMAT 03 04 03 GE 3104</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems
Find the Numerical solutions of Non-linear equations
Familiarize the students with advantages and limitations of numerical techniques
Solve interpolation problems, difference equations and Eigen value problems</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit I Nature of numerical computations: errors and their propagation</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Numerical solution of systems of linear equations: Direct methods for solving linear systems, error analysis. The residual correction method. Iteration methods, Error prediction and Acceleration.</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Matrix Eigenvalue problem: Eigenvalue location, error, and stability results, Power method. Orthogonal transformations using Householder matrices. The eigenvalues of a symmetric Tridiagonal matrix. QR method. The calculation of Eigenvectors and Inverse iteration.</td><td>18</td></tr>
<tr><td colspan="8">Unit-IV: Numerical solutions of Non-linear equations: Solution of non-linear equations by iterative methods, acceleration of convergence. Newton’s methods for polynomials,</td><td>18</td></tr>
</table>

quotient-difference algorithms. Numerical solution of system of Non-linear equations.	
Unit-V: Interpolation: Interpolating polynomial and its construction using Lagrange methods and methods of differences, iterated interpolation, method of divided differences, inverse interpolation, Hermite Interpolation. The general Hermite interpolation problem. Spline function and their use.	18

References:

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.
2. R.L. Burden and J.D. Faires: Numerical analysis, 7th edition, Brooks Cole, 2001.
3. P.J. Davis: Interpolation and Approximation, Dover, 1975.
4. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.
5. S.S. Sastry: Introductory Methods of Numerical Analysis, Phi Learning, 2009.

Lab Component: Exposure to MATLAB/Mathematica and computational experiments based on the algorithms discussed in the course.

10. Teaching-Learning Process

- Lectures
- Discussions
- Simulations
- Role Plays
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-enabled Learning

11. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face-to-face classroom methods with computer-based activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments face-to-face learning, giving ample freedom and flexibility to the students and teachers to access and explore wide range of open-access resources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face-to-face learning. The blended learning does not undermine the role of a teacher; rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each Program, be adopted

12. Assessment and Evaluation

- Continuous Comprehensive Evaluation at regular intervals after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the program instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations

- Review of Literature
- Collaborative Assignments

13. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Program Outcomes
- Program Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation
- Multiple Entry
- Multiple Exit

14. References

- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website, https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf
- Guidelines for Multiple Entry and Exit in Academic Programs offered in Higher Education Institutions, https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/abc_doc.pdf
- National Education Policy-2020, https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- Quality Mandate for Higher Education in India, https://www.ugc.ac.in/e-book/Quality%20Mandate%20E-BOOK/mobile/index.html
- The draft subject specific LOCF templates available on UGC website, https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==

15. Appendix

Courses of 5-year integrated BSc-MSc Mathematics having similarity more than 50% with corresponding MOOC courses have been identified, perused and discussed. These are recommended to be included for offering as equivalent courses:

List of Courses in Integrated BSc-MSc, and MSc Mathematics programs:

Sr.	CUH Program/Semester	CUH Course Title/Type(credits)	MOOC Course	Similarity
1	BSc-MSc (Integ.)/ 1ST	Calculus /Core (6)	Calculus of One Real Variable	75-80%
2	BSc-MSc (Integ.)/ 2ND	Multivariate Calculus /Core (6)	Calculus of Several Real Variables	75-80%
3	BSc-MSc (Integ.)/ 2ND	Ordinary Differential Equations/Core (6)	Differential Equations	70%
4	BSc-MSc (Integ.)/ 3RD	Group Theory /Core (6)	Introduction to Abstract Group Theory	85%
5	BSc-MSc (Integ.)/ 3RD	Probability Theory and Statistics /Core (6)	Introduction to Probability Theory and Statistics	80%
6	BSc-MSc (Integ.)/ 3RD	Real Analysis/Core (6)	Real Analysis	90%
7	BSc-MSc (Integ.)/ 4TH, 5TH	Advanced Algebra /Core (6) Linear Algebra /Core (6)	Introduction to Abstract and Linear Algebra	60% 50%
8	BSc-MSc (Integ.)/ 4TH	Partial Differential Equations and Calculus of Variation /Core (6)	Partial Differential Equations	65%
9	BSc-MSc (Integ.)/ 5TH, MSc 1ST	Linear Algebra /Core (6, 4)	Linear Algebra	75-80%
10	BSc-M.Sc (Integ.)/ 6TH	Numerical Methods /Core (6)	Numerical Methods	75-80%
11	BSc-MSc (Integ.)/ 6TH MSc/1ST	Complex Analysis/Core (6, 4)	Complex Analysis	80%
12	MSc/ 1ST, 4TH	Algebra-I /Core (4) Algebra-II /Core (4)	Rings and Modules	50% 50%
13	MSc /3 RD	Operations Research /DSEC (4)	Operations Research	90%
14	MSc /4TH	Measure Theory and Integration /DSEC (4)	Measure Theory	90%

MOOC courses (SWAYAM) having similarity more than 75% with the core courses may be offered to the students. For SEC/GEC/AECC/DCEC/DSEC courses, the students may opt from the MOOC courses provided these courses are not in the list of core courses and student have not studied similar courses earlier. Since, the list of MOOC courses (SWAYAM) keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

Structure of Question Papers and Marks Distribution

		Distribution of Marks
		(Max. Marks=100)
Continuous Assessment		**Max. Marks=30**
	Sessional-I	10
	Sessional-II	10
	Quiz/Assignment	5
	Attendance	5
End Term Examination **(3 Hours)**		**Max. Marks=70**
		(i) Question 1 has seven sub-parts (short answer-type) at least one from each unit and students need to answer any five. Each sub-part carries 2 Marks. (5x2=10) (ii) Question 2 to 6 (one from each unit) have three sub-parts each, and students need to answer any two. Each sub-part carries 6 marks. (2x6x5=60 marks).

Annexure-III

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(**NAAC Accredited ‘A’ Grade**)

Curriculum and Syllabi

Integrated BSc-MSc (Mathematics)

(w.e.f. 2022-23)

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	√
Approval Date :	10/05/2022	14/05/2022	
Approval Date :	06/09/2022	12/09/2022	07/10/2022

Table of Contents

VISION AND MISSION

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavors and scholarly inquiry

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

Vision and Mission of the Department

Vision

To be an internationally recognized centre for research and teaching in Mathematics. To encourage excellence, innovation, integrity and values for society in the department. To produce global leaders for academic and industry by imparting multidisciplinary and contemporary mathematical knowledge to the students.

Mission

- To contribute towards building calibre of the students by providing quality education and research in Mathematics through updated curriculum, effective teaching learning process.
- To impart innovative skills, team-work, and ethical practices to the students so as to meet societal expectations.
- To build a strong base in Mathematics for various academic programs across the institute.

1. Background

i) Preamble

The LOCF (Learning Outcomes based Curriculum Framework) committee constituted by University Grants Commission (UGC) submitted its report concerning the syllabi for Integrated BSc-MSc (Mathematics). The committee discussed the framework of syllabi in its meetings and suggested implementation of these syllabi in the Departments/Schools of Mathematics in Universities/Colleges/Institutes based on following facts:

1. The learning outcomes of each course/paper are designed so that these may help learners to understand the main objectives of studying the course.
2. This will enable learners to select elective courses/papers depending on the individual inclinations and contemporary requirements.
3. The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to graduate degree with honours in Mathematics or with Mathematics as a subject.
4. These syllabi in Mathematics under CBCS are recommended keeping in view applications of Mathematics in science, engineering, social science, business and a host of other areas.
5. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.
6. The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the courses/papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.
7. The outcomes of each course/paper may be modified as per the local requirements.
8. The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help learners to complete the study of concerned paper in certain periods and prepare them for examinations.
9. The papers are organized considering the credit load in a particular semester. The core courses/papers of general interest are suggested for semesters I to IV. The elective courses and advanced courses are proposed for the Integrated BSc-MSc (Mathematics) students of semesters V and VI.

10. Mathematics is a vast subject with immense diversity. Hence, it is very difficult for every student to learn each branch of Mathematics, even though each paper has its unique importance. Under these circumstances, LOCF in Mathematics suggests a number of elective papers along with compulsory papers. A student can select elective papers as per her/his needs and interests.

11. The committee expects that the papers may be taught using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima and R to strengthen the conceptual understanding and to widen up the horizon of students' self-experience.

12. The committee of the LOCF in Mathematics expects that the concerned departments/colleges/institutes/universities will encourage their faculty members to include necessary topics in addition to courses suggested by LOCF committee. It is hoped that the needs of all round development in the careers of learners/students will be fulfilled by the recommendations of LOCF in Mathematics.

ii) Introduction:

One of the significant reforms in the undergraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, especially in Mathematics, and the prevalent utilitarian world view of the society. The learning outcomes are attained by students through skills acquired during a Program of study. Program learning outcomes will include subject-specific skills and generic skills, including transferable global skills and competencies. It would also focus on knowledge and skills that prepare students for further study, employment, and citizenship. They help ensure comparability of learning levels and academic standards across colleges/universities and provide a broad picture of the level of competence of graduates.

The quality education in a subject like Mathematics is a very challenging task for Higher Education System in India. UGC has already taken an appropriate measure to define the minimum levels of learning for Mathematics courses for undergraduate and post-graduate levels. The quality of higher education in Mathematics should be improved in such a manner that young minds are able to compete in this field globally in terms of their knowledge and skills in the globalized era of the date. Also, there is an urgent need of sustained initiatives to be taken by colleges/institutes/universities for outcome-oriented higher education in

Mathematics so that graduates are enabled to enhance the chances of employability. Presently, the goal of higher education in Mathematics may be achieved using the following measures:

i. Curriculum reform based on learning outcomes-based curriculum framework (LOCF).
ii. Improving learning environment and academic resources.
iii. Elevating the quality of teaching and research.
iv. Involving students in discussions, problem-solving and out of box thinking about various ideas of Mathematics and their applicability, which may lead to empowerment and enhancement of the social welfare at large.
v. Encouraging the learners to make use of LOCF to learn Mathematics through distance education.
vi. Motivating the learners to understand various concepts of Mathematics keeping in view the regional context.
vii. Enabling learners to create research atmosphere in mathematical sciences in their colleges/institutes/universities.
viii. Teach courses of Mathematics based on Choice Based Credit System (CBCS).

One of the benchmarks to measure progress of a country is the advancement of knowledge of Mathematics. Hence, innovative measures should be taken to improve the quality of mathematical knowledge in our society. This is also because Mathematics has wide ranging applications in engineering, technology and a host of other areas.

iii) Learning Outcomes Based Approach to Curriculum Planning:

The Integrated BSc-MSc (Mathematics) degree is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements sought to be acquired by learners at the end of these Programs. Hence, the learning outcomes of Mathematics for these courses are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for knowledge of Mathematics.

The LOCF in Mathematics has helped in designing courses in the light of graduate attributes, description of qualifications, courses and Program learning outcomes. The committee has tried to frame the syllabi of Mathematics courses in such a way that it may lead to all round development and delivery of complete curriculum. Hence, it provides specific guidelines to the learners to acquire sufficient knowledge during this Program.

The objective of LOCF (Mathematics) is to prepare the syllabi having standard level of study. It is also aimed at prescribing standard norms for teaching-learning process and examination pattern. Hence, the Program has been chalked out in such manner that there is scope of flexibility and innovation in

i. modifications of prescribed syllabi.

ii. teaching-learning methodology.

iii. assessment technique of students and knowledge levels.

iv. learning outcomes of courses.

v. inclusion of new elective courses subject to availability of experts in colleges/institutes/universities across the country.

iv) Nature and Extent of Integrated BSc-MSc (Mathematics) Program:

Mathematics is the study of quantity, structure, space and change. It has very broad scope in science, engineering and social sciences. The key areas of study in Mathematics are:

1. Calculus
2. Algebra
3. Geometry
4. Differential Equations
5. Analysis
6. Mechanics

Degree programs in Mathematics cover topics which are already mentioned in details under various headings in Section 6. The depth and breadth of study of individual topics depend on the nature and devotion of learners in specific Mathematics Programs.

As a part of effort to enhance employability of Mathematics graduates, the courses have been designed to include learning experiences, which offer them opportunities in various sectors of human activities. In this context, the experience of the project work in the areas of applications of Mathematics has a key role.

2. Aims of Integrated BSc-MSc (Mathematics) Program:

The overall aims of Integrated BSc-MSc (Mathematics) Program are as follows:

- To create deep interest in learning Mathematics.
- To develop broad and balanced knowledge and understanding of definitions, concepts, principles and theorems.
- To familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.

- To enhance the ability of learners to apply the knowledge and skills acquired by them during the Program to solve specific theoretical and applied problems in mathematics.
- To provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
- To encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

3. Key Outcomes Underpinning Curriculum Planning and Development

The LOCF in Mathematics desires to propose the courses of Mathematics for Integrated BSc-MSc (Mathematics), based on the expected learning outcomes and academic standards which are necessary for the graduates after completing these Programs. The committee considered and discussed the following factors seriously:

i. Framing of syllabi
ii. Learners attributes
iii. Qualification descriptors
iv. Program learning outcomes
v. Course learning outcomes
vi. Necessity of having elective courses
vii. Applications of Mathematics
viii. Employability in banking, finance and other sectors.

4. Integrated BSc-MSc Attributes

The graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

4.1 Disciplinary knowledge:

Capability of demonstrating comprehensive knowledge of Mathematics and understanding of one or more disciplines which form a part of an undergraduate program of study.

4.2 Communications skills:

4.2.1 Ability to communicate various concepts of Mathematics effectively using examples and their geometrical visualizations.

4.2.2 Ability to use Mathematics as a precise language of communication in other branches of human knowledge.

4.2.3 Ability to communicate long standing unsolved problems in Mathematics.

4.2.4 Ability to show the importance of Mathematics as a precursor to various scientific developments since the beginning of the civilization.

4.2.5 Ability to explain the development of Mathematics in the civilizational context and its role as queen of all sciences.

4.3 Critical thinking and analytical reasoning:

4.3.1 Ability to employ critical thinking in understanding the concepts in every area of Mathematics.

4.3.2 Ability to analyze the results and apply them in various problems appearing in different branches of Mathematics.

4.4 Problem solving:

4.4.1 Capability to solve problems in computer graphics using concepts of linear algebra.

4.4.2 Capability to solve various models such as growth and decay models, radioactive decay model, drug assimilation, LCR circuits and population models using techniques of differential equations.

4.4.3 Ability to solve linear system of equations, linear programming problems and network flow problems.

4.4.4 Ability to provide new solutions using the domain knowledge of Mathematics acquired during this Program.

4.5 Research-related skills:

4.5.1 Capability for inquiring about appropriate questions relating to the concepts in various fields of Mathematics.

4.5.2 To know about the advances in various branches of Mathematics.

4.6 Information/digital literacy:

4.6.1 Capability to use appropriate softwares to solve system of equations and differential equations.

4.6.2 Capability to understand and apply the programming concepts of C++ to mathematical investigations and problem solving.

4.7 Self-directed learning:

Ability to work independently and do in-depth study of various notions of Mathematics.

4.8 Moral and ethical awareness/reasoning:

Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

4.9 Lifelong learning:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate habit of self-learning.

5. Qualification descriptors for Integrated BSc-MSc (Mathematics) Program

The qualification descriptors suggest generic outcomes and attributes to be obtained while obtaining the degree of Integrated BSc-MSc (Mathematics) Program. The qualification descriptors indicate the academic standards on the basis of following factors:

i. Level of knowledge
ii. Understanding
iii. Skills
iv. Competencies and attitudes
v. Values.

These parameters are expected to be attained and demonstrated by the learners after becoming graduates in these Programs. The colleges/institutes/universities should consider the above mentioned parameters at the time of designing, approving, assessing and reviewing academic Programs containing common courses for Integrated BSc-MSc (Mathematics) Program. The learning experiences and assessment procedures should be so designed that every graduate with Mathematics may achieve the Program learning outcomes with equal opportunity irrespective of the class, gender, community and regions. Each graduate in Mathematics should be able to:

i. demonstrate fundamental systematic knowledge of Mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhance the subject specific knowledge and help in creating jobs in various sectors.
ii. demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.
iii. apply knowledge, understanding and skills to identify the difficult/unsolved problems in Mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.
iv. fulfill one's learning requirements in Mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences.
v. apply one's disciplinary knowledge and skills in Mathematics in newer domains and uncharted areas.
vi. identify challenging problems in Mathematics and obtain well-defined solutions.
vii. exhibit subject-specific transferable knowledge in Mathematics relevant to job trends and employment opportunities.

6. Program Learning Outcomes of Integrated BSc-MSc (Mathematics)

Bachelor's degree in Mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of Mathematics. This also leads to study of related areas like computer science and statistics. Thus, this Program helps learners in building a solid foundation for higher studies in Mathematics.

1. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.
2. Students undergoing this Program learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn to behave responsibly in a rapidly changing interdependent society.

3. Students completing this Program will be able to present Mathematics clearly and precisely, make vague ideas precise by formulating them in the language of Mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of Mathematics to non-mathematicians.
4. Completion of this Program will also enable the learners to join teaching profession in primary and secondary schools.
5. This Program will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

7. Structure of Integrated BSc-MSc (Mathematics) Program

The Integrated BSc-MSc (Mathematics) is five-year degree program divided into 10 semesters. A student is to earn the required credits as per University ordinance and UGC guidelines. The scheme and syllabi of the program are subject to change according to the UGC guidelines, NEP 2020 and University ordinance.

Duration: Integrated BSc-MSc (Mathematics) is a full-time integrated program offered by the Department of Mathematics. This is a 5-year program, consisting of 10 semesters, two per year.

Eligibility: 10+2 in Science Streams or equivalent from any recognized board in India with Mathematics as one of the subjects having minimum 50% marks or equivalent grade in aggregate for UR category and 45% or equivalent grade for SC/ST/OBC/PWD/EWS candidates.

7.1 Course learning outcomes

Course learning outcomes of each course in Integrated BSc-MSc (Mathematics) Program have been enshrined in the beginning of course contents of each course.

B.Sc. (Hons) Mathematics

CORE COURSES (14)

Program outcomes	Calculus	Algebra and Geometry	Multivariable Calculus	Ordinary Differential Equations	Real Analysis	Group Theory	Probability and Statistics	Mechanics	Linear Algebra	Partial Differential Equations and Calculus of Variations	Set Theory and Metric Spaces	Advanced Algebra	Complex Analysis	Numerical Analysis
Disciplinary knowledge	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Communication skills	√	√	√	√	√	√	√		√	√	√	√	√	
Critical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Analytical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Problem solving	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Research related skills				√						√		√	√	
Information literacy	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Digital literacy			√				√							√
Self-directed learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lifelong learning	√	√	√	√	√		√			√	√	√	√	√
Professional skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Applicational skills	√		√	√			√	√	√	√				√
Experimental learning	√	√	√	√	√		√	√	√	√			√	√
Employability options	√		√				√		√	√				√

DISCIPLINE SPECIFIC ELECTIVE COURSES (Any Four)

Program	**Tensors and Differential Gemetry**	**Mathematical Logic**	**Integral Transforms and Fourier Analysis**	**Linear Programming**	**Information Theory and Coding**	**Graph Theory**	**Special Theory and Relativity**	**Discrete Mathematics**	**Wavelets and Applications**	**Number Theory**	**Mathematical Finance**	**C++ Programming for Mathematics**	**Cryptography**	**Advanced Mechanics**	Dissertation on Any Topic of Mathematics
Disciplinary knowledge	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Communication skills	√	√			√	√		√	√		√	√		√	
Critical thinking	√	√	√	√	√	√		√	√	√	√	√	√	√	√
Analytical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Problem solving	√	√	√	√	√	√	√	√	√	√	√		√	√	
Research related skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Information literacy			√	√	√				√			√			
Digital literacy			√	√	√				√			√			
Self-directed learning	√	√	√	√	√	√		√	√	√	√	√		√	√
Lifelong learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Professional skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Applicational skills			√	√	√	√		√	√		√	√	√		
Experimental learning				√	√	√		√	√		√	√	√		
Employability options				√	√			√	√		√	√	√		

7.1.1 Credit distribution for Integrated BSc-MSc (Mathematics) Program

Sr.	Nature of Courses/Papers *(up to 6th Semester)*	Total No. of Courses/Papers	Credits in Theory+ (Tutorial/Practical)	Total Credits
1.	Core	14	06	84
2.	Discipline Specific Electives	04	06	24
3.	Generic Electives /Interdisciplinary	04	06	24
4.	Ability Enhancement	02	04	08
5.	Skill Enhancement	02	04	08
Total Courses/Credits		28	--	148

8. Course Type

Core Courses (CC)

Discipline Specific Elective Courses (DSEC)

Generic Elective Courses (GEC)

Ability Enhancement Compulsory Courses (AECC)

Skill Enhancement Courses (SEC)

Total Credits: Semester-wise credits (*up to 6th* semester**): 22+ 22+ 28 + 28+24+24**

CORE COURSES (CC)

Sr.	Course code	Course title	L	T	P	Credits
1.	SBSMAT 03 01 01 C 5106	Calculus	5	1	0	6
2.	SBSMAT 03 01 02 C 5106	Algebra and Geometry	5	1	0	6
3.	SBSMAT 03 02 01 C 5106	Multivariable Calculus	5	1	0	6
4.	SBSMAT 03 02 02 C 5106	Ordinary Differential Equations	5	1	0	6
5.	SBSMAT 03 03 01 C 5106	Real Analysis	5	1	0	6
6.	SBSMAT 03 03 02 C 5106	Group Theory	5	1	0	6
7.	SBSMAT 03 03 03 C 5106	Probability and Statistics	5	1	0	6
8.	SBSMAT 03 04 01 C 5106	Mechanics	5	1	0	6
9.	SBSMAT 03 04 02 C 5106	Linear Algebra	5	1	0	6
10.	SBSMAT 03 04 03 C 5106	Partial Differential Equations and Calculus of Variation	5	1	0	6
11.	SBSMAT 03 05 01 C 5106	Set Theory and Metric Spaces	5	1	0	6
12.	SBSMAT 03 05 02 C 5106	Advanced Algebra	5	1	0	6
13.	SBSMAT 03 06 01 C 5106	Complex Analysis	5	1	0	6
14.	SBSMAT 03 06 02 C 4046	Numerical Analysis	4	0	4	6

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSEC)

Sr.	Course code	Course title	L	T	P	Credits
1.	SBSMAT 03 05 01 DSE 5106	Tensors and Differential Geometry	5	1	0	6
2.	SBSMAT 03 05 02 DSE 5106	Mathematical Logic	5	1	0	6
3.	SBSMAT 03 05 03 DSE 5106	Integral Transforms and Fourier Analysis	5	1	0	6
4.	SBSMAT 03 05 04 DSE 5106	Linear Programming	5	1	0	6
5.	SBSMAT 03 05 05 DSE 5106	Information and Coding Theory	5	1	0	6
6.	SBSMAT 03 05 06 DSE 5106	Graph Theory	5	1	0	6
7.	SBSMAT 03 05 07 DSE 5106	Special Theory of Relativity	5	1	0	6
8.	SBSMAT 03 06 01 DSE 5106	Discrete Mathematics	5	1	0	6
9.	SBSMAT 03 06 02 DSE 5106	Wavelets and Applications	5	1	0	6
10.	SBSMAT 03 06 03 DSE 5106	Number Theory	5	1	0	6
11.	SBSMAT 03 06 04 DSE 5106	Mathematical Finance	5	1	0	6
12.	SBSMAT 03 06 05 DSE 5106	Cryptography	5	1	0	6
13.	SBSMAT 03 06 06 DSE 5106	Advanced Mechanics	5	1	0	6
14.	SBSMAT 03 06 07 DSE 5106	Dissertation on Any Topic of Mathematics	5	1	0	6

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)*:

Sr.	Course Code	Course Title	L	T	P	Credits
1.	SBSMAT 03 01 01 AECC 3104	Environmental Sciences	3	1	0	4
2.	SBSMAT 03 02 01 AECC 3104	**प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)**	3	1	0	4
3.	SBSMAT 03 02 02 AECC 3104	**हिंदी भाषा : रचना एवं व्यवहार**	3	1	0	4
4.	SBSMAT 03 02 03 AECC 3104	English	3	1	0	4

SKILL ENHANCEMENT ELECTIVE COURSES (SEC)*:

The department may offer more than one course depending on the specialization and strength of faculty members. The students have to opt for one course from Sr. 1 and 2 in 3rd semester and one from Sr. 3 and 4 in 4th semester from the following.

Sr.	Course Code	Course Title	L	T	P	Credits
1.	SBSMAT 03 03 01 SEC 3104	Logic, Sets and Graph Theory	3	1	0	4
2.	SBSMAT 03 03 02 SEC 3024	Computer Fundamentals and Programming in C	3	0	2	4
3.	SBSMAT 03 04 01 SEC 3024	Object Oriented Programming in C++(P)	3	0	2	4
4.	SBSMAT 03 04 02 SEC 3104	Linux Operating System and Computer Graphics	3	1	0	4

*** 1. University/Department may add more choices for Ability Enhancement Compulsory and Skill Enhancement Elective Courses.**

2. The AECC course Environmental Sciences **is compulsory, whereas one out of the remaining three AECC courses (प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च, हिंदी भाषा: रचना एवं व्यवहार and English/MIL) will be taught in first/second semester according to availability of faculty members in respective departments.**

9. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

Scheme and Syllabi of Integrated BSc-MSc (Mathematics)

(CHOICE BASED CREDIT SYSTEM)

Semester I

Total credits: 22

Sr.	Course Title	Course Code	L	T	P	Credits
1	Calculus	SBSMAT 03 01 01 C 5106	5	1	0	6
2	Algebra and Geometry	SBSMAT 03 01 02 C 5106	5	1	0	6
3	AECC1		3	1	0	4
4	GE1		5	1	0	6

Semester II

Total credits: 22

Sr.	Course Title	Course Code	L	T	P	Credits
1	Multivariable Calculus	SBSMAT 03 02 01 C 5106	5	1	0	6
2	Ordinary Differential Equations	SBSMAT 03 02 02 C 5106	5	1	0	6
3	AECC2		3	1	0	4
4	GE2		5	1	0	6

Semester III

Total credits: 28

Sr.	Course Title	Course Code	L	T	P	Credits
1	Real Analysis	SBSMAT 03 03 01 C 5106	5	1	0	6
2	Group Theory	SBSMAT 03 03 02 C 5106	5	1	0	6
3	Probability and Statistics	SBSMAT 03 03 03 C 5106	5	1	0	6
4	SEC1		3	1/0	0/2	4
5	GE3		5	1	0	6

Semester IV

Total credits: 28

Sr.	Course Title	Course Code	L	T	P	Credits
1	Mechanics	SBSMAT 03 04 01 C 5106	5	1	0	6
2	Linear Algebra	SBSMAT 03 04 02 C 5106	5	1	0	6
3	Partial Differential Equations and Calculus of Variation	SBSMAT 03 04 03 C 5106	5	1	0	6
4	SEC2		3	1/0	0/2	4
5	GE4		5	1	0	6

Semester V

Total credits: 24

Sr.	Course Title	Course Code	L	T	P	Credits
1	Set Theory and Metric Spaces	SBSMAT 03 05 01 C 5106	5	1	0	6
2	Advanced Algebra	SBSMAT 03 05 02 C 5106	5	1	0	6
3	DSE1		5	1	0	6
4	DSE2		5	1	0	6

Semester VI

Total credits: 24

Sr.	Course Title	Course Code	L	T	P	Credits
1	Complex Analysis	SBSMAT 03 06 01 C 5106	5	1	0	6
2	Numerical Analysis	SBSMAT 03 06 02 C 4046	4	0	4	6
3	DSE3		5	1	0	6
4	DSE4		5	1	0	6

8. COURSE-LEVEL LEARNING OUTCOMES

Course Structure

SEMESTER – I

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Continuous Assessment	Lab	Total Marks
SBSMAT 03 01 01 C 5106	Calculus	6	105	45	-	150
SBSMAT 03 01 02 C 5106	Algebra and Geometry	6	105	45	-	150
AECC1		4	70	30	-	100
GEC1		6	105	45	-	150
Total marks of Semester-I						550

Note : The other conditions will remain the same as per relevant Ordinance and regulations of the University.

<table>
<tr><td>Course No: 1</td><td colspan="2">Course Name: Calculus</td><td colspan="5">Course Code: SBSMAT 03 01 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, compactness, differentiability, and integrability, rigorously defined. Students should also have attained a basic level of competency in developing their own mathematical skills.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
• Calculate the limit and examine the continuity of a function at a point.
• Understand the consequences of various mean value theorems for differentiable functions.
• Sketch curves in Cartesian and polar coordinate systems.
• Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td colspan="7">Unit-I: Sequences and Integration
Real numbers, Sequences of real numbers, Convergence of sequences and series, Bounded and monotonic sequences; Definite integral as a limit of sum, Integration of irrational algebraic functions and transcendental functions, Reduction formulae, Definite integrals.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Limit and Continuity
ε-δ definition of limit of a real valued function, Limit at infinity and infinite limits;</td><td>18</td></tr>
</table>

Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity.	
Unit-III: Differentiability Differentiability of a real valued function, Geometrical interpretation of differentiability, Relation between differentiability and continuity, Differentiability and monotonicity, Chain rule of differentiation; Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems; Successive differentiation, Leibnitz's theorem.	18
Unit-IV: Expansion of Functions Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlomilch forms of remainder; Maxima and minima.	18
Unit-V: Curvature, Asymptotes and Curve Tracing Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves.	18

References:

1. George B. Thomas Jr., R L Finney. Calculus and Analytical Geometry (14th edition). Pearson Education, **(Textbook).**
2. Howard Anton, I. Bivens & Stephan Davis (2016). Calculus (10th edition). Wiley India.
3. Gabriel Klambauer (1986). Aspects of Calculus. Springer-Verlag.
4. Wieslaw Krawcewicz & Bindhyachal Rai (2003). Calculus with Maple Labs. Narosa.

<table>
<tr><td colspan="1">Course No: 2</td><td colspan="2">Course Name: Algebra and Geometry</td><td colspan="6">Course Code: SBSMAT 03 01 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. Students can develop geometry with a degree of confidence and will gain fluency in the basics of Euclidean geometry. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the importance of roots of real and complex polynomials, learn various methods of obtaining roots and Familiarize with relations, equivalence relations and partitions.
Employ De Moivre’s theorem in a number of applications to solve numerical problems.
Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
Find eigenvalues and corresponding eigenvectors for a square matrix.
Explain the properties of three dimensional shapes.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Theory of Equations and Complex Numbers
Elementary theorems on the roots of an equations including Cardan’s method, The remainder and factor theorems, Synthetic division, Factored form of a polynomial, The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots, Integral and rational roots; Polar representation of complex numbers, The nth roots of unity, De Moivre’s theorem for integer and rational indices and its applications.</td><td>18</td></tr>
</table>

Unit-II: Relations and Basic Number Theory Relations, Equivalence relations, Equivalence classes; Functions, Composition of functions, Inverse of a function; Finite, countable and uncountable sets; The division algorithm, Divisibility and the Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences; Principles of mathematical induction and well ordering.	18
Unit-III: Row Echelon Form of Matrices and Applications Systems of linear equations, Row reduction and echelon forms, Linear independence, The rank of a matrix and applications; Introduction to linear transformations, The matrix of a linear transformation, Matrix operations, Determinants, The inverse of a matrix, Characterizations of invertible matrices; Applications to Computer Graphics; Eigenvalues and eigenvectors, The characteristic equation and the Cayley-Hamilton theorem.	18
Unit-IV: Planes, Straight Lines and Spheres Planes: Distance of a point from a plane, Angle between two planes, pair of planes, Bisectors of angles between two planes; Straight lines: Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane; Spheres: Different forms, Intersection of two spheres, Orthogonal intersection, Tangents and normal, Radical plane, Radical line, Coaxial system of spheres, Pole, Polar and Conjugacy.	18
Unit-V: Locus, Surfaces, Curves and Conicoids Space curves, Algebraic curves, Ruled surfaces, Some standard surfaces, Classification of quadric surfaces, Cone, Cylinder, Central conicoids, Tangent plane, Normal, Polar planes, and Polar lines.	18

References:

1. Robert J. T. Bell (1994). An Elementary Treatise on Coordinate Geometry of Three Dimensions. Macmillan India Ltd, **(Textbook).**

2. Mark V. Lawson (2020). Algebra and Geometry. 2^{nd} edition, CRC Press **(Textbook).**

3. Titu Andreescu, & Dorin Andrica (2014). Complex Numbers from A to...Z. (2nd edition). Birkhäuser.

4. D. Chatterjee (2009). Analytical Geometry: Two and Three Dimensions. Narosa Publishing House.

5. Leonard Eugene Dickson (2009). First Course in the Theory of Equations. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)

6. Edgar G. Goodaire & Michael M. Parmenter (2015). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education Pvt. Ltd. India.

7. Bernard Kolman & David R. Hill (2003). Introductory Linear Algebra with Applications (7th edition). Pearson Education Pvt. Ltd. India.

8. David C. Lay, Steven R. Lay & Judi J. McDonald (2016). Linear Algebra and its Applications (5th edition). Pearson Education Pvt. Ltd. India.

<table>
<tr><td>Course No: 03</td><td colspan="2">Course Name:
Environmental Sciences</td><td colspan="5">Course Code: SBSMAT 03 01 01 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 2</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="7">To create awareness for sustainable development, problems of pollution, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, depletion of ozone layer, loss of biodiversity and need of worldwide efforts in its conservation.</td></tr>
<tr><td></td><td colspan="7">After going through this course the students will be able to
• Get the knowledge about trends of biological diversity and conservation strategies and thereafter be able to create awareness for its conservation and development.
• Understanding of issues concerning different natural resources will be helpful to find scientific solution based on participatory approach.
• Know about the local environmental issues, movements and an important role to minimize the impact of these aspects.
• Knowledge about the types of pollution and pollution control.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I: Scope of the Environmental Science and Natural resources Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.	12
Unit-II: Introduction and structure of Ecosystem Introduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem :- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems.	12

Unit-III: Bio- Geographical Classification Introduction – Definition, value and types: genetic, species and ecosystem diversity. Bio-geographical classification and Hot-spots of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation.	12
Unit-IV: Control Measures of Pollution Definition, cause, effects and control measures of Air, Water, Soil, Marine and Noise pollution. Solid Waste Management: Causes, effects and control measures of wastes.	12
Unit-V: Public Awareness Seventeen Sustainable Developmental Goals, Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, Public awareness.	12

References:

1. Bharucha E, (2002) The Biodiversity of India, Map in Publishing
2. Cao G, Orru R (2014) Current Environmental Issues and Challenges. 2014th edition; Springer
3. Cunningham W P, Cunningham M A (2008) Principles of Environment Science. Enquiry and Applications. 5th Edition. Tata McGraw Hill, New Delhi
4. Dash M C, Dash S P (2009) Fundamentals of Ecology. 3rd McGraw Hill Education
5. Gibbs J, Malcolm L, Sterling J (2008) Problem-Solving in Conservation Biology and Wildlife Management. 2nd ed. Wiley-Blackwell
6. Ginley D, Cahen, D (2011) Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press
7. Gilbert M (2007) An Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi
8. Khan I (2019) Forest Governance and Sustainable Resource Management. SAGE Publications. India.
9. Odum E P, Barrett W, (2005) Fundamentals of Ecology. 5th ed. Cengage Learning.
10. Sharma P D (2017) Ecology and Environment. 13th ed. Rastogi Publications.
11. Thangadurai D, Ching G, Jeyabalan S, Islam S (2019) Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. United States: Apple Academic Press

<table>
<tr><td>Course No: 04</td><td colspan="2">Course Name: ******** GE1</td><td colspan="5">Course Code: ******* GE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
</table>

SEMESTER – II

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 02 01 C 5106	Multivariable Calculus	6	105	45	-	150
SBSMAT 03 02 02 C 5106	Ordinary Differential Equations	6	105	45	-	150
AECC2		4	70	30	-	100
GEC2		6	105	45	-	150
Total marks of Semester-II						550

<table>
<tr><td>Course No: 05</td><td colspan="2">Course Name: Multivariable Calculus</td><td colspan="5">Course Code: SBSMAT 03 02 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Learn conceptual variations while advancing from one variable to several variables in calculus.
Apply multivariable calculus in optimization problems.
Inter-relationship amongst the line integral, double and triple integral formulations.
Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.
Realize importance of Green’s, Gauss’s and Stokes’ theorems in other branches of mathematics.</td></tr>
</table>

Content of Each Unit	**Hours**
Unit-I: Partial Differentiation Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.	18
Unit-II: Differentiation Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler’s theorem for homogeneous functions, Taylor’s theorem for functions of two variables and more variables, Envelopes and evolutes.	18

Unit-III: Extrema of Functions and Vector Field Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems, Definition of vector field, Divergence, curl, gradient and vector identities.	18
Unit-IV: Double and Triple Integrals Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals, Dirichlet integral.	18
Unit-V: Green's, Stokes' and Gauss Divergence Theorem Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.	18

References:

1. George B. Thomas Jr., R L Finney. Calculus and Analytical Geometry (14th edition). Pearson Education, **(Textbook).**
2. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage, **(Textbook).**
3. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited.
4. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition). Pearson Education. Dorling Kindersley (India) Pvt. Ltd.

<table>
<tr><td>Course No: 06</td><td colspan="3">Course Name:
Ordinary Differential Equations</td><td colspan="5">Course Code: SBSMAT 03 02 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated
BSc-MSc
(Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce ordinary differential equations, general, particular, explicit, implicit and singular solutions of a differential equation. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Understand the genesis of ordinary differential equations.
• Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
• Know Picard’s method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.
• Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
• Formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: First Order Differential Equations
Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, differential Equations in which variables are separable, Homogeneous differential equations, Linear differential equations and equations reducible to linear form, Exact differential equations,</td><td>18</td></tr>
</table>

Integrating factor, First order higher degree differential equations solvable for x, y and p. Clairaut's form and singular solutions. Picard's method of successive approximations and the statement of Picard's theorem for the existence and uniqueness of the solutions of the first order differential equations.	
Unit-II: Second Order Linear Differential Equations Statement of existence and uniqueness theorem for linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients, Reduction of order, Coupled linear differential equations with constant coefficients.	18
Unit-III: Higher Order Linear Differential Equations Principle of superposition for a homogeneous linear differential equation, Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous differential equations of higher order with constant coefficients, Euler-Cauchy equation, Method of variation of parameters and method of undetermined coefficients, Inverse operator method.	18
Unit-IV: Series Solutions of Differential Equations Power series method, Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials, Frobenius method, Bessel's equation, Bessel functions and their properties, Recurrence relations.	18
Unit-V: Applications Orthogonal trajectories, Acceleration-velocity model, Minimum velocity of escape from Earth's gravitational field, Growth and decay models, Malthusian and logistic population models, Radioactive decay, Drug assimilation into the blood of a single cold pill; Free and forced mechanical oscillations of a spring suspended vertically carrying a mass at its lowest tip, Phenomena of resonance, LCR circuits, Lotka-Volterra population model.	18

References:

1. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India, **(Textbook).**

2. E.A. Coddington and N. Levinson (2016). Theory of Ordinary Differential Equations (18th

edition), Tata McGRAW-Hill.

3. Belinda Barnes & Glenn Robert Fulford (2015). Mathematical Modelling with Case Studies: A Differential Equation Approach Using Maple and MATLAB (2nd edition). Chapman & Hall/CRC Press, Taylor & Francis.
4. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.
5. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
6. George F. Simmons (2017). Differential Equations with Applications and Historical Notes (3rd edition). CRC Press. Taylor & Francis.
7. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd edition). Narosa.

<table>
<tr><td>Course No: 07</td><td colspan="4">Course Name:
प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)</td><td colspan="4">Course Code: SBSMAT 03 02 01
AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective /उद्देश्यः</td><td colspan="8">1. संस्कृतेतर-विषयाणामध्येतृभ्यः संस्कृताध्ययनाय सौकर्योत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां वेदादि-शास्त्राणामुपनिषदां च रुचिरुत्पादनम्; 3. संस्कृतेनोपनिबद्धानां नीतिवाक्यानां गीतायां वर्णितस्य कर्मयोगस्य च तत्त्व-संधारणाय यत्नः; 4. सामान्य-भाषाविज्ञानस्य परिचयः।</td></tr>
<tr><td></td><td colspan="8">पाठ्यक्रमाध्ययनस्य फलम् / Course Level Learning Outcome:
●अध्येतारः वेदादि-शास्त्राणामुपनिषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नशीलाः भवेयुः।
●व्यावहारिकदृष्ट्या संस्कृतज्ञानेन अन्यविषयाणामध्येतारः तत्तद् स्वविषयानुगुणं संस्कृतभाषायामुप- लभ्यमानानां ग्रन्थानां प्रति यत्नशीलाः स्युः।
●वेदोपनिषत्–गीता–नीतिशास्त्र–भाषाशास्त्रादीनां विषयाणां सम्यगध्ययनेनास्माकं पूर्वजानां वैदुष्येण परिचयः संजायेत।
●भारतीय-चिन्तनपरम्परायाः समृद्धिं ज्ञातुमयं पाठ्यक्रमः प्रकृष्टमाध्यमः संजायेत।</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td>I</td><td colspan="7">घटकम्-1: (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)</td><td>12</td></tr>
<tr><td>II</td><td colspan="7">घटकम्-2: भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः</td><td>12</td></tr>
<tr><td>III</td><td colspan="7">घटकम्-3: भगवद्गीता – तृतीयाध्यायः (कर्मयोगः)</td><td>12</td></tr>
<tr><td>IV</td><td colspan="7">घटकम्-4: सामान्यभाषाविज्ञानम्- (क) वर्णमाला, वर्णानाम् उच्चारणस्थानानि</td><td>12</td></tr>
</table>

	प्रयत्नाश्च;	
V	**घटकम्-5:** सामान्यभाषाविज्ञानम्- भाषाविज्ञानस्य सामान्यः परिचयः, भाषापरिवर्तनस्य कारणानि, अर्थपरिवर्तनस्य कारणानि च	12

अनुशंसितग्रन्थाः -

1. उवव्ट-महीधर, शुक्लयजुर्वेदभाष्य, मोतीलाल बनारसीदास, दिल्ली, 2007

2. स्वामी दयानन्द सरस्वती, यजुर्वेदभाष्य, सम्पा० ब्रह्मदत्त जिज्ञासु, रामलाल कपूर ट्रस्ट, सोनीपत (हरियाणा)

3. तैत्तिरीयोपनिषद्, हिन्दी व्याख्याकार - स्वामी प्रखर प्रज्ञानन्द सरस्वती, काशी, 2013

4. भर्तृहरि, नीतिशतक, सम्पादक एवं हिन्दी व्याख्याकार - जनार्दन शास्त्री पाण्डेय, मोतीलाल बनारसीदास, दिल्ली, 2014

5. नीतिशतकम्, 'नीतिपथ' हिन्दी व्याख्याकार - राजेश्वर शास्त्री मुसलगाँवकर, चौखम्भा, वाराणसी

6. श्रीमद्भगवद्गीता (हिन्दी अनुवाद सहित), गीता प्रैस, गोरखपुर, 2015

7. श्रीकृष्ण त्रिपाठी, श्रीमद्भगवद्गीता (द्वितीय, तृतीय एवं चतुर्थ अध्याय), 2005

8. देवीदत्त शर्मा, भाषिकी और संस्कृत भाषा, हरियाणा साहित्य अकादमी, चण्डीगढ़, 1990

9. कपिलदेव द्विवेदी, भाषा-विज्ञान एवं भाषा-शास्त्र, विश्वविद्यालय प्रकाशन, चौक, वाराणसी, 2012

10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ

11. Burrow, T., The Sanskrit Language, 2016

12. Gune, P.D., An Introduction to Comparative Philology, Oriental Book House, Poona, 1958

13. The Taittirīya Upaniṣad, Eng. Tr. and Commentary by Swami Muni Narayana Prasad, D.k. Print world (P), Ltd., New Delhi-2009

14. The Nīti and Vairāgya Śatakas of Bhartrihari, M.R. Kale, Motilal Banarsidass, Delhi, 2017.

<table>
<tr><td>Course No: 08</td><td colspan="5">Course Name: हिंदी भाषा : रचना एवं व्यवहार.</td><td colspan="3">Course Code: SBSMAT 03 02 02 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="8">• भाषा, व्याकरण एवं साहित्य के सामान्य स्वरूप का निदर्शन।</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">● भाषा, बोली और व्याकरण के विविध घटकों का परिचय।
● संचार माध्यमों के स्वरूप और भाषा का ज्ञान।
● रचना पाठ से साहित्य बोध।</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit –I भाषा और व्याकरण
भाषा की परिभाषा एवं विशेषताएं
भाषा और व्याकरण
हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)</td><td>12</td></tr>
<tr><td colspan="8">Unit –II हिंदी की संवैधानिक स्थिति
हिंदी भाषा व बोलियों का संक्षिप्त परिचय
हिंदी की संवैधानिक स्थिति : राजभाषा, संपर्क भाषा और राष्ट्रभाषा
कार्यालयी हिंदी : पल्लवन, संक्षेपण, टिप्पण
पत्र लेखन : सरकारी, अर्द्ध-सरकारी</td><td>12</td></tr>
<tr><td colspan="8">Unit –III संचार माध्यमों का स्वरूप एवं भाषा
संचार माध्यमों का स्वरूप एवं भाषा</td><td>12</td></tr>
</table>

संचार माध्यमों का सामाजिक प्रभाव कंप्यूटर में हिंदी का अनुप्रयोग	
Unit -IV **कहानी : चंद्रधर शर्मा 'गुलेरी' :** उसने कहा था; **प्रेमचंद :** नशा **निबंध : हजारी प्रसाद द्विवेदी :** नाखून क्यों बढ़ते हैं; **बालमुकुंद गुप्त :** बनाम लार्ड कर्जन	12
Unit -V **कविता : सूर्यकांत त्रिपाठी 'निराला' :** वर दे, वीणा वादिनी वर दे ! **जयशंकर प्रसाद :** हिमाद्रि तुंग शृंग से	12

अनुशंसित पुस्तकें :

1. हिंदी : उद्भव, विकास और रूप; डॉ हरदेव बाहरी; किताब महल इलाहाबाद; 1969.
2. हिंदी भाषा; डॉ भोलानाथ तिवारी; किताब महल, इलाहाबाद; 2004.
3. हिंदी व्याकरण; कामता प्रसाद गुप्त; नागरी प्रचारिणी सभा, काशी; 1927.
4. व्यावहारिक हिंदी व्याकरण तथा रचना; हरदेव बाहरी; लोकभारती प्रकाशन, इलाहाबाद; 1972.
5. कंप्यूटर और हिंदी; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2015.
6. रेडियो और दूरदर्शन पत्रकारिता; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2017.

<table>
<tr><td>Course No: 09</td><td colspan="3">Course Name: English</td><td colspan="5">Course Code: SBSMAT 03 02 03 AECC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills. Some of these are:
Language of communication, various speaking skills such as personal communication, social interactions and communication in professional situations such as interviews, group discussions and office environments, important reading skills as well as writing skills such as report writing, notetaking etc.
While, to an extent, the art of communication is natural to all living beings, in today's world of complexities, it has also acquired some elements of science. It is hoped that after studying this course, students will find a difference in their personal and professional interactions.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit –I: Theory of Communication
Introduction: Theory of Communication, Types and modes of Communication. Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication</td><td>12</td></tr>
</table>

Unit –II: Speaking Skills Speaking Skills: Monologue Dialogue, Group Discussion, Effective Communication/ Mis- Communication, Interview Public Speech	12
Unit –III: Comprehension Summary Reading and Understanding, Close Reading, Comprehension Summary, Paraphrasing.	12
Unit –IV: Analysis and Interpretation Analysis and Interpretation, Translation(from Indian language to English and vice-versa) ,Literary/Knowledge Texts	12
Unit –V: Writing Skills Writing Skills, Documenting, Report Writing, Making notes, Letter writing	12

References:

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brati Biswas.

Course No: 10	**Course Name: ******** GE2		**Course Code: ******* GE 5106**				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: II**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – III

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 03 01 C 5106	Real Analysis	6	105	45	-	150
SBSMAT 03 03 02 C 5106	Group Theory	6	105	45	-	150
SBSMAT 03 03 03 C 5106	Probability and Statistics	6	105	45	-	150
SEC1		4	70	30	-	100
GE3		6	105	45	-	150
Total marks of Semester-III						700

<table>
<tr><td>Course No: 11</td><td colspan="3">Course Name: Real Analysis</td><td colspan="5">Course Code: SBSMAT 03 03 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighborhood of a point, countable sets , sequence and series, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand many properties of the real line ℝ and learn to define sequence in terms of functions from ℝ to a subset of ℝ.
• Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
• Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
• Learn some of the properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Real Number System
Algebraic and order properties of ℝ, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of ℝ, The completeness property of ℝ, Archimedean property, Density of rational numbers in ℝ, Definition and types of intervals, Nested intervals property; Neighborhood of a point in ℝ, Open, closed and</td><td>18</td></tr>
</table>

perfect sets in ℝ, Connected subsets of ℝ, Cantor set and Cantor function.	
Unit-II: Sequences of Real Numbers Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion.	18
Unit-III: Infinite Series Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series; Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, Integral test; Alternating series, Leibniz test, Absolute and conditional convergence, Rearrangement of series and Riemann's theorem.	18
Unit-IV: Riemann Integration Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems.	18
Unit-V: Uniform convergence and Improper integral: Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M-test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiability, Improper integrals, Dirichlet test and Abel's test for improper integrals.	18

References:

1. Robert G. Bartle & Donald R. Sherbert (2015). Introduction to Real Analysis (4th edition).Wiley India**, (Textbook).**
2. W. Rudin (2017), Real and Complex Analysis, Tata McGRAW Hill.
3. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough (2015). An Introduction to Analysis (2nd edition), Jones and Bartlett India Pvt. Ltd.
4. K. A. Ross (2013). Elementary Analysis: The Theory of Calculus (2nd edition). Springer.

<table>
<tr><td>Course No: 12</td><td colspan="3">Course Name: Group Theory</td><td colspan="5">Course Code: SBSMAT 03 03 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce basic structures of algebra like group, dihedral groups, permutation group, Abelian group, non-Abelian group and cyclic group which are the main pillars of modern group theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Recognize the mathematical objects called groups.
• Link the fundamental concepts of groups and symmetries of geometrical objects.
• Explain the significance of the notions of cosets, normal subgroups, and factor groups.
• Analyze consequences of Lagrange's theorem.
• Learn about structure preserving maps between groups and their consequences.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Groups and its Elementary Properties
Symmetries of a square, Definition and examples of groups including dihedral, permutation and quaternion groups, Elementary properties of groups.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Subgroups and Cyclic Groups
Subgroups and examples of subgroups, Cyclic groups, Properties of cyclic groups, Lagrange's theorem, Euler phi function, Euler's theorem, Fermat's little theorem.</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Normal Subgroups
Properties of cosets, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Classification of subgroups of cyclic groups.</td><td>18</td></tr>
</table>

Unit-IV: Permutation Groups Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups, Cayley's theorem and its applications.	18
Unit-V: Group Homomorphisms, Rings and Fields Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Properties of isomorphisms; First, second and third isomorphism theorems for groups; Definitions and elementary properties of rings and fields.	18

References:

1. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage, **(Textbook).**
2. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson **(Textbook)**.
3. Michael Artin (2014). Algebra (2nd edition). Pearson.
4. I.N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
5. Nathan Jacobson (2009). Basic Algebra I (2nd edition). Dover Publications.
6. Ramji Lal (2017). Algebra 1: Groups, Rings, Fields and Arithmetic. Springer.
7. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.

<table>
<tr><td colspan="2">Course No: 13</td><td colspan="3">Course Name: Probability and Statistics</td><td colspan="5">Course Code: SBSMAT 03 03 03 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td colspan="2" rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="9">To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses. After taking this course, students will be able to use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB, to perform simple and sophisticated analyses for large samples.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">After going through this course the students will be able to
• Understand distributions in the study of the joint behaviour of two random variables.
• Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
• Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.</td></tr>
<tr><td colspan="9">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="9">Unit-I: Probability Functions and Moment Generating Function
Basic notions of probability, Conditional probability and independence, Baye’s theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.</td><td>18</td></tr>
<tr><td colspan="9">Unit-II: Univariate Discrete and Continuous Distributions
Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.</td><td>18</td></tr>
</table>

Unit-III: Bivariate Distribution Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.	18
Unit-IV: Correlation, Regression and Central Limit Theorem The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.	18
Unit-V: Modeling Uncertainty Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.	18

References:

1. Irwin Miller &Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India, **(Textbook).**
2. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.
6. V.K. Kapoor and S. C. Gupta (2018). Fundamental of Mathematical Statistics, S. Chand & Sons.

<table>
<tr><td>Course No: 14</td><td colspan="3">Course Name:
Logic, Sets and Graph Theory</td><td colspan="5">Course Code: SBSMAT 03 03 01 SEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="8">To introduce students with the fundamental concepts in set, logic and graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Analyze the truth and falsity of a logical statement and differentiate between a logical statement and an ordinary statement.
Define and describe various properties of sets.
Describe the fundamental properties of Graph Theory.
Identify different representations of a Graph for practical applications.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Logic
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.</td><td>12</td></tr>
<tr><td colspan="8">Unit-II: Set Theory
Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.</td><td>12</td></tr>
</table>

Unit-III: Relation on Sets Difference and Symmetric difference of two sets. Set identities, generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.	12
Unit-IV: Graph Theory Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles.	12
Unit-V: Application of Graph Theory The adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd- Warshall algorithm, Tree, Binary tree, rooted tree, spanning tree.	12

References:

1. Rosen, K. H. Discrete Mathematics and Its Applications. 7th edition, Tata McGraw Hill, 2011, **(Textbook).**
2. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003, **(Textbook).**
3. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education,2018.
4. Lipschutz, S., Lipson, M.L. and Patil, V.H. *Discrete Mathematics.* Schaum's Outline Series, Tata McGraw-Hill Education, 2020.
5. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge,1990.

<table>
<tr><td>Course No: 15</td><td colspan="3">Course Name: Computer Fundamentals and Programming in C</td><td colspan="5">Course Code: SBSMAT 03 03 02 SEC 3024</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td colspan="2">Total Hours: 75</td></tr>
<tr><td>Course Objective</td><td colspan="8">To familiarize the students with problem solving through C-programming. The course aims to give exposure to basic concepts of the C-programming. The lab component of this course is designed to provide hands-on-training with the concepts.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Write and run a C program along with gradual improvement using efficient error handling.
Implement selective structures and repetitive structures in C programs using different control statements.
To emphasize on the importance of use of pointers for efficient C programming.
Use structures and unions in a C program for handling multivariate data.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I: C **Language Preliminaries** An overview of Programming, Programming Language, Classification. Basic structure of a C Program, C language preliminaries. Operators and Expressions, Bit - Manipulation Operators, Bitwise Assignment Operators, Decisions and looping.	15
Unit-II: Arrays and Pointers Arrays and Pointers, Encryption and Decryption. Pointer Arithmetic, Passing Pointers as Function Arguments, Accessing Array Elements through Pointers, Passing Arrays as Function Arguments. Multidimensional Arrays. Arrays of Pointers, Pointers to Pointers.	15

Unit-III: Storage Classes Storage Classes –Fixed vs. Automatic Duration. Scope. Global Variables. Definitions and Allusions. The Register Specifier. ANSI rules for the Syntax and Semantics of the Storage Class Keywords.	15
Unit-IV: Structures and Unions Dynamic Memory Allocation. Structures and Unions. enum declarations. Passing Arguments to a Function, Declarations and Calls, Automatic Argument Conversions, Pointers to Functions.	15
Unit-V: C Preprocessors The C Preprocessors, Macro Substitution. Include Facility. Conditional Compilation. Line Control. Input and Output -Streams. Buffering. Error Handling. Opening and Closing a File. Reading and Writing Data. Selecting an I/O Method. Unbuffered I/O. Random Access. The Standard Library for I/O.	15

References:

1. Y. Kanetkar (2020), Let us C, 15th edition, BPB Publication, **(Textbook)**.
2. Brian W. Kernighan & Dennis M. Ritchie, The C Program Language, Second Edition (ANSI features), Prentice Hall 2019.
3. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 2003.
4. Samuel P. Harkison and Gly L. Steele Jr., C: A Reference Manual, Second Edition, Prentice Hall, 2014.
5. Balagurusamy E: Programming in ANSI C, Third Edition, Tata McGraw-Hill Publishing Co. Ltd., 2018.
6. Byron, S. Gottfried: Theory and Problems of Programming with C, Second Edition (Schaum Outline Series), Tata McGraw-Hill Publishing Co. Ltd., 2017.
7. Venugopal K. R. and Prasad S. R.: Programming with C , Tata McGraw-Hill Publishing Co. Ltd., 2020.

Course No: 16	**Course Name: ********** GE3		**Course Code: *********** GE 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: III**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – IV

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 04 01 C 5106	Mechanics	6	105	45	-	150
SBSMAT 03 04 02 C 5106	Linear Algebra	6	105	45	-	150
SBSMAT 03 04 03 C 5106	Partial Differential Equations and Calculus of Variation	6	105	45	-	150
SEC1		4	70	30		100
GE4		6	105	45	-	150
Total marks of Semester-IV						700

<table>
<tr><td>Course No: 17</td><td colspan="3">Course Name: Mechanics</td><td colspan="5">Course Code: SBSMAT 03 04 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 08</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Familiarize with subject matter, which has been the single centre, to which wer drawn mathematicians, physicists, astronomers, and engineers together.
Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.
Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.
Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Statics
Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.</td><td>18</td></tr>
</table>

Unit-II: Centres of Gravity and Common Catenary Centres of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.	18
Unit-III: Rectilinear Motion Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity, Motion of varying mass.	18
Unit-IV: Motion in a Plane Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates; Motion in a vertical circle, projectiles in a vertical plane and cycloidal motion.	18
Unit-V: Central Orbits Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion.	18

References:

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books, **(Textbook).**
2. P. L. Srivastava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad,
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill.
4. A. S. Ramsey (2009). Statics. Cambridge University Press.
5. A. S. Ramsey (2009). Dynamics. Cambridge University Press.
6. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd.

<table>
<tr><td>Course No: 18</td><td colspan="4">Course Name: Linear Algebra</td><td colspan="3">Course Code: SBSMAT 03 04 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation, vector space, linear transformation and inner product spaces which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
Relate matrices and linear transformations, compute eigen values and eigen vectors of linear transformations.
Learn properties of inner product spaces and determine orthogonality in inner product spaces.
Realise importance of adjoint of a linear transformation and its canonical form.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Vector Spaces
Definition and examples, Subspace, Linear span, Quotient space and direct sum of subspaces, Linearly independent and dependent sets, Bases and dimension.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Linear Transformations
Definition and examples, Algebra of linear transformations, Matrix of a linear transformation, Change of coordinates, Rank and nullity of a linear transformation and rank-nullity theorem.</td><td>18</td></tr>
</table>

Unit-III: Further Properties of Linear Transformations Isomorphism of vector spaces, Isomorphism theorems, Dual and second dual of a vector space, Transpose of a linear transformation, Eigen vectors and eigen values of a linear transformation, Characteristic polynomial and Cayley-Hamilton theorem, Minimal polynomial.	18
Unit-IV: Inner Product Spaces Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalisation, Diagonalisation of symmetric matrices.	18
Unit-V: Adjoint of a Linear Transformation and Canonical Forms Adjoint of a linear operator; Hermitian, unitary and normal linear transformations; Jordan canonical form, Triangular form, Trace and transpose, Invariant subspaces.	18

References:

1. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra, (4thedition). Prentice-Hall of India Pvt. Ltd, **(Textbook).**
2. Vivek Sahai & Vikas Bist (2013). Linear Algebra (2nd Edition). Narosa Publishing House, **(Textbook).**
3. Kenneth Hoffman & Ray Kunze (2015). Linear Algebra (2nd edition). Prentice-Hall.
4. M. Gel'fand (1989). Lectures on Linear Algebra. Dover Publications.
5. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
6. Serge Lang (2005). Introduction to Linear Algebra (2nd edition). Springer India.
7. Gilbert Strang (2014). Linear Algebra and its Applications (2nd edition). Elsevier.

Course No: 19	Course Name: Partial Differential Equations and Calculus of Variations					Course Code: SBSMAT 03 04 03 C 5106		
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem**: IV	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	To introduce partial differential equations, general, particular, explicit, implicit and singular solutions of a partial differential equation. This course further explains the analytic techniques in computing the solutions of various partial differential equations.						
Course Outcomes	After going through this course the students will be able to • Apply a range of techniques to solve first & second order partial differential equations. • Model physical phenomena using partial differential equations such as the heat and wave equations. • Understand problems, methods and techniques of calculus of variations.						

Content of Each Unit	**Hours**
Unit-I: First Order Partial Differential Equations Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.	18
Unit-II: Second Order Partial Differential Equations with Constant Coefficients Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients.	18
Unit-III: Second Order Partial Differential Equations with Variable Coefficients Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDE, Reduction to canonical or normal form; Monge's method; Solution of heat and wave equations in one and two dimensions by method of separation of variables.	18

Unit-IV: Calculus of Variations-Variational Problems with Fixed Boundaries Euler's equation for functional containing first order and higher order total derivatives, Functionals containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.	18
Unit-V: Calculus of Variations-Variational Problems with Moving Boundaries Variational problems with moving boundaries, Functionals dependent on one and two variables, One sided variations. Sufficient conditions for an extremum-Jacobi and Legendre conditions, Second variation.	18

References:

1. I. N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications, **(Textbook).**
2. A. S. Gupta (2004). Calculus of Variations with Applications. PHI Learning, **(Textbook).**
3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
4. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equation for Scientists and Engineers (4th edition). Springer India**.**
5. H. T. H. Piaggio (2004). An Elementary Treatise on Differential Equations and Their Applications. CBS Publishers.
6. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.
7. L.C. Evans (2014), Partial Differential Equations, American Mathematical Society, Indian 2^{nd} edition.

<table>
<tr><td>Course No: 20</td><td colspan="3">Course Name: Object Oriented Programming in C++</td><td colspan="5">Course Code: SBSMAT 03 04 01 SEC 3024</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 75</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Write C++-Programs to solve Mathematical problems.
Design algorithms to solve problems.
Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism.
Emphasize on the importance of use of Friend Functions for efficient C++ programming.</td></tr>
</table>

Content of Each Unit	Hours
Unit-I Characteristics of Object-Oriented Programming Languages OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.	15
Unit-II Implementing OOPS Concepts in C++ Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables with Functions.	15

Unit-III Abstract Data Types Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers – private, public and protected.	15
Unit-IV Implementing Class Functions Implementing Class Functions within Class declaration or outside the Class declaration. Instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members. Understanding Compile Time, Polymorphism, function overloading, Rules of Operator Overloading (Unary and Binary) as member function/friend function,	15
Unit-V Implementation of Operator Overloading Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator, concepts of namespaces.	15

References:

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997, **(Textbook).**
2. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000, **(Textbook).**
3. B. Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, Object Oriented Programming with C++, BPB Publication.
5. B. Stroustrup , The C++ Programming Language, 3rd Ed., Addison Welsley.

<table>
<tr><td>Course No: 21</td><td colspan="3">Course Name: Linux Operating System and Computer Graphics</td><td colspan="5">Course Code: SBSMAT 03 04 02 SEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course introduces the Role and purpose of the operating system, Functionality of a typical operating system, managing atomic access to OS objects. Detailed study of computer graphics, 2 D and 3 D transformations, representations and visualization.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Test the Linux process model and explain how Linux schedule processes and provide inter- process communication
Explore how linux implements files systems and manages input output devices.
Identify the core concepts of computer graphics
Apply graphics programming techniques to create and design computer graphics scans</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I Linux – The Operating System
Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux’s relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security.</td><td colspan="2">12</td></tr>
<tr><td colspan="7">Unit-II Linux – The General Characteristics
The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.</td><td colspan="2">12</td></tr>
</table>

Unit-III Resource Management in Linux Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.	12
Unit-IV Development of Computer Graphics Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices.	12
Unit-V Computer Graphics of Conic-Section Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.	12

References:

1. A. Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education,2008, **(Textbook).**
2. K. Cox, Red Hat Linux Administrator's Guide, PHI,2009, **(Textbook).**
3. R. Stevens, UNIX Network Programming, 3rd Ed., PHI,2008.
4. S. Das, Unix Concepts and Applications, 4th Ed., TMH,2009.
5. E. Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed., O'Reilly Media,2009.
6. N. Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed.,2004.
7. D. Hearn and M.P. Baker, Computer Graphics, 2nd Ed., Prentice–Hall of India,2004.
8. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, Computer Graphics: Principals and Practices, 2nd Ed., Addison-Wesley, MA,1990.
9. D.F. Rogers, Procedural Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 2001.
10. D.F. Rogers and A.J. Admas, Mathematical Elements in Computer Graphics, 2nd Ed., McGraw Hill, 1990.

Course No: 22	**Course Name: ********** GE4		**Course Code: ********* GE 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: IV**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – V

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 05 01 C 5106	Set Theory and Metric Spaces	6	105	45	-	150
SBSMAT 03 05 02 C 5106	Advanced Algebra	6	105	45	-	150
DSE1		6	105	45	-	150
DSE2		6	105	45	-	150
Total marks of Semester-V						600

<table>
<tr><td>Course No: 23</td><td colspan="3">Course Name:
Set Theory and Metric Spaces</td><td colspan="5">Course Code: SBSMAT 03 05 01 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To providing the basic knowledge pertaining to metric spaces such as open and closed balls, neighborhood, interior, closure, subspace, continuity, compactness, connectedness etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Learn basic facts about the cardinality of a set.
Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano-Weierstrass property, compactness, and connectedness.
Identify the continuity of a function defined on metric spaces and homeomorphisms</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Theory of Sets
Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder-Bernstein theorem, Cantor’s theorem, Order relation in cardinal numbers, Arithmetic of cardinal numbers, Partially ordered set, Zorn’s lemma and Axiom of choice, Various set theoretic paradoxes.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Concepts in Metric Spaces
Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.</td><td>18</td></tr>
</table>

Unit-III: Complete Metric Spaces and Continuous Functions Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle.	18
Unit-IV: Compactness Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces.	18
Unit-V: Connectedness Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.	18

References:

1. E. T. Copson (1988). Metric Spaces. Cambridge University Press, **(Textbook).**
2. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa, **(Textbook).**
3. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa**, (Textbook).**
4. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
5. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.
6. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-Hill.
7. P. R. Halmos (1974). Naive Set Theory. Springer.

<table>
<tr><td>Course No: 24</td><td colspan="2">Course Name: Advanced Algebra</td><td colspan="5">Course Code: SBSMAT 03 05 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce modern structures of algebra like group actions, orbits and stabilizers, rings and fields, field extensions and finite fields which are the main pillars of modern algebra. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the basic concepts of group actions and their applications.
Recognize and use the Sylow theorems to characterize certain finite groups.
Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Group Actions
Group actions, Orbits and stabilizers, Conjugacy classes, Orbit-stabilizer theorem, Normalizer of an element of a group, Center of a group, Class equation of a group, Inner and outer automorphisms of a group.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Sylow Theorems
Cauchy’s theorem for finite abelian groups, Finite simple groups, Sylow theorems and applications including nonsimplicity tests.</td><td>18</td></tr>
</table>

Unit-III: Rings and Fields Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, principal and maximal ideals, Relation between integral domain and field, Euclidean rings and their properties, Wilson and Fermat's theorems.	18
Unit-IV: Polynomial Rings Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain.	18
Unit-V: Field Extensions and Finite Fields Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Perfect field, Classification of finite fields.	18

References:

1. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley, **(Textbook)**.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press, **(Textbook).**
3. Michael Artin (2014). Algebra (2nd edition). Pearson.
4. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
6. N. S. Gopalakrishnan (1986). University Algebra, New Age International Publishers.
7. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
8. Thomas W. Hungerford (2004). Algebra (8th edition). Springer.
9. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
10. Serge Lang (2002). Algebra (3rd edition). Springer-Verlag.
11. I. S. Luthar & I. B. S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
12. I. S. Luthar & I. B. S. Passi (2012). Algebra: Volume 2: Rings. Narosa.

<table>
<tr><td>Course No: 25</td><td colspan="3">Course Name: Tensors and Differential Geometry</td><td colspan="5">Course Code: SBSMAT 03 05 01 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Explain the basic concepts of tensors.
• Understand role of tensors in differential geometry.
• Learn various properties of curves including Frenet-Serret formulae and their applications.
• Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae.
• Understand the role of Gauss’s Theorem a Egregium and its consequences.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I: Tensors
Contravariant and covariant vectors, Transformation formulae, Tensor product of two vector spaces, Tensor of type (r, s), Symmetric and skew-symmetric properties, Contraction of tensors, Quotient law, Inner product of vectors.</td><td colspan="2">18</td></tr>
<tr><td colspan="7">Unit-II: Further Properties of Tensors
Fundamental tensors, Associated covariant and contravariant vectors, Inclination of two vectors and orthogonal vectors, Christoffel symbols, Law of transformation of Christoffel symbols, Covariant derivatives of covariant and contravariant vectors, Covariant differentiation of tensors, Curvature tensor, Ricci tensor, Curvature tensor identities.</td><td colspan="2">18</td></tr>
</table>

Unit-III: Curves in $\mathbb{R}^2$ and $\mathbb{R}^3$ Basic definitions and examples, Arc length, Curvature and the Frenet-Serret formulae, Fundamental existence and uniqueness theorem for curves, Non-unit speed curves.	18
Unit-IV: Surfaces in $\mathbb{R}^3$ Basic definitions and examples, The first fundamental form, Arc length of curves on surfaces, Normal curvature, Geodesic curvature, Gauss and Weingarten formulae, Geodesics, Parallel vector fields along a curve and parallelism.	18
Unit-V: Geometry of Surfaces The second fundamental form and the Weingarten map; Principal, Gauss and mean curvatures; Isometries of surfaces, Gauss's Theorem Egregium, The fundamental theorem of surfaces, Surfaces of constant Gauss curvature, Exponential map, Gauss lemma, Geodesic coordinates, The Gauss-Bonnet formula and theorem.	18

References:

1. Alferd Gray (2018). Modern Differential Geometry of Curves and Surfaces with Mathematica (4th edition). Chapman & Hall/CRC Press, Taylor & Francis, **(Textbook).**
2. A. Pressley ().Elementary Differential Geometry. 2^{nd} edition, Springer, **(Textbook)**.
3. Christian Bär (2010). Elementary Differential Geometry. Cambridge University Press.
4. Manfredo P. do Carmo (2016). Differential Geometry of Curves & Surfaces (Revised and updated 2nd edition). Dover Publications.
5. Richard S. Millman & George D. Parkar (1977). Elements of Differential Geometry. Prentice-Hall.
6. R. S. Mishra (1965). A Course in Tensors with Applications to Riemannian Geometry. Pothishala Pvt. Ltd**.**
7. Sebastián Montiel & Antonio Ross (2009). Curves and Surfaces. American Mathematical Society.

<table>
<tr><td>Course No: 26</td><td colspan="3">Course Name: Mathematical Logic</td><td colspan="5">Course Code: SBSMAT 03 05 02 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objective of the course is to introduce basic structures of language, propositional logic, completeness theorem and Interpretation in a theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Learn the syntax of first-order logic and semantics of first-order languages.
• Understand the propositional logic and basic theorems like compactness theorem, meta theorem and post-tautology theorem.
• Assimilate the concept of completeness interpretations and their applications with special emphasis on applications in algebra.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Syntax of First-order Logic
First-order languages, Terms of language, Formulas of language, First order theory.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Semantics of First-order Languages
Structures of first order languages, Truth in a structure, Model of a theory, Embeddings and isomorphism.</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Propositional Logics
Syntax of propositional logic, Semantics of propositional logic, Compactness theorem for propositional logic, Proof in propositional logic, Meta theorem in propositional logic, Post tautology theorem.</td><td>18</td></tr>
</table>

Unit-IV: Proof and Meta Theorems in First-order Logic Proof in first-order logic, Meta theorems in first-order logic, Some meta theorem in arithmetic, Consistency and completeness.	18
Unit-V: Completeness Theorem and Model Theory Completeness theorem, Interpretation in a theory, Extension by definitions, Compactness theorem and applications, Complete theories, Applications in algebra.	18

References:

1. Elliott Mendelson (2015). Introduction to Mathematical Logic (6th edition). Chapman & Hall/CRC, **(Textbook).**
2. Shashi Mohan Srivastava (2013). A Course on Mathematical Logic (2nd edition). Springer, **(Textbook).**
3. Richard E. Hodel (2013). An Introduction to Mathematical Logic. Dover Publications.
4. Yu I. Manin (2010). A Course in Mathematical Logic for Mathematicians (2nd edition). Springer.

<table>
<tr><td>Course No: 26</td><td colspan="3">Course Name: Integral Transforms and Fourier Analysis</td><td colspan="5">Course Code: SBSMAT 03 05 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The course is aimed at exposing the students to learn the Laplace transforms and Fourier transforms. To equip with the methods of finding Laplace transform and Fourier Transforms of different functions. To make them familiar with the methods of solving differential equations, partial differential equations, IVP and BVP using Laplace transforms and Fourier transforms.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Know about piecewise continuous functions, Dirac delta function, Laplace transforms and its properties.
Solve ordinary differential equations using Laplace transforms.
Familiarise with Fourier transforms of functions belonging to $L^1(\mathbb{R})$ class, relation between Laplace and Fourier transforms.
Explain Parseval's identity, Plancherel's theorem and applications of Fourier transforms to boundary value problems.
Learn Fourier series, Bessel's inequality, term by term differentiation and integration of Fourier series.
Apply the concepts of the course in real life problems.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Laplace Transforms
Laplace transform, Linearity, Existence theorem, Laplace transforms of derivatives and integrals, Shifting theorems, Change of scale property, Laplace transforms of periodic functions, Dirac's delta function.</td><td>18</td></tr>
</table>

Unit-II: Further Properties of Laplace Transforms and Applications Differentiation and integration of transforms, Convolution theorem, Integral equations, Inverse Laplace transform, Lerch's theorem, Linearity property of inverse Laplace transform, Translations theorems of inverse Laplace transform, Inverse transform of derivatives, Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations.	18
Unit-III: Fourier Transforms Fourier and inverse Fourier transforms, Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Linearity property, Change of scale property, Shifting property, Modulation theorem, Relation between Fourier and Laplace transforms.	18
Unit-IV: Solution of Equations by Fourier Transforms Solution of integral equation by Fourier sine and cosine transforms, Convolution theorem for Fourier transform, Parseval's identity for Fourier transform, Plancherel's theorem, Fourier transform of derivatives, Applications of infinite Fourier transforms to boundary value problems, Finite Fourier transform, Inversion formula for finite Fourier transforms.	18
Unit-V: Fourier Series Fourier cosine and sine series, Fourier series, Differentiation and integration of Fourier series, Absolute and uniform convergence of Fourier series, Bessel's inequality, The complex form of Fourier series.	18

References:

1. James Ward Brown & Ruel V. Churchill (2011). Fourier Series and Boundary Value Problems. McGraw-Hill Education, **(Textbook).**
2. Walter Rudin (2017). Fourier Analysis on Groups. Dover Publications, **(Textbook).**
3. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press.
4. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley,.
5. A. Zygmund (2002).Trigonometric Series (3rd edition). Cambridge University Press.

<table>
<tr><td>Course No: 27</td><td colspan="3">Course Name: Linear Programming</td><td colspan="5">Course Code: SBSMAT 03 05 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, Assignment and Game Problem. Such problems arise in manufacturing resource planning and financial sectors.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Analyze and solve linear programming models of real life situations.
Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
Understand the theory of the simplex method.
Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.
Learn about the applications to transportation, assignment and two-person zero-sum game problems.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Linear Programming Problem, Convexity and Basic Feasible Solutions
Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Simplex Method
Optimality criterion, Improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.</td><td>18</td></tr>
</table>

Unit-III: Duality Formulation of the dual problem, Duality theorems, Complimentary slackness theorem, Economic interpretation of the dual, Dual-simplex method.	18
Unit-IV: Sensitivity Analysis Changes in the cost vector, right-hand side vector and the constraint matrix of the linear programming problem.	18
Unit-V: Applications Transportation Problem: Definition and formulation, Methods of finding initial basic feasible solutions: Northwest-corner rule, Least- cost method, Vogel approximation method; Algorithm for obtaining optimal solution. Assignment Problem: Mathematical formulation and Hungarian method.Game Theory: Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method for solving a game.	18

References:

1. G. Hadley (2002). Linear Programming. Narosa Publishing House, **(Textbook).**
2. Hamdy A. Taha (2017). Operations Research: An Introduction (10th edition). Pearson, **(Textbook).**
3. Frederick S. Hillier & Gerald J. Lieberman (2015). Introduction to Operations Research (10th edition). McGraw-Hill Education.
4. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali (2010). Linear Programming and Network Flows (4th edition). John Wiley & Sons.
5. Paul R. Thie & Gerard E. Keough (2014). An Introduction to Linear Programming and Game Theory (3rd edition). Wiley India Pvt. Ltd.

<table>
<tr><td>Course No: 28</td><td colspan="3">Course Name:
Information and Coding Theory</td><td colspan="5">Course Code: SBSMAT 03 05 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The Mathematics program promotes mathematical skills and knowledge for their intrinsic beauty, effectiveness in developing proficiency in analytical reasoning, and utility in modeling and solving real world problems. Students who have learned to logically question assertions, recognize patterns, and distinguish the essential and irrelevant aspects of problems can think deeply and precisely, nurture the products of their imagination to fruition in reality, and share their ideas and insights while seeking and benefiting from the knowledge and insights of others.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Study simple ideal statistical communication models.
Understand the development of codes for transmission and detection of information.
Learn about the input and output of a signal via transmission channel.
Study detection and correction of errors during transmission.
Represent a linear code by matrices - encoding and decoding.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Concepts of Information Theory
Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Entropy Function
A sketch of communication network, Entropy, Basic relationship among different</td><td>18</td></tr>
</table>

entropies, A measure of mutual information, Interpretation of Shannon's fundamental inequalities; Redundancy, efficiency, and channel capacity; Binary symmetric channel, Binary erasure channel, Uniqueness of the entropy function, Joint entropy and conditional entropy, Relative entropy and mutual information, Chain rules for entropy, Conditional relative entropy and conditional mutual information, Jensen's inequality and its characterizations, The log sum inequality and its applications.	
Unit-III: Concepts of Coding Block codes, Hamming distance, Maximum likelihood decoding, Levels of error handling, Error correction, Error detection, Erasure correction, Construction of finite fields, Linear codes, Matrix representation of linear codes, Hamming codes.	18
Unit-IV: Bounds of Codes Orthogonality relation, Encoding and decoding of linear codes, The singleton bound and maximum distance separable codes, The sphere-packing bound and perfect codes, The Gilbert-Varshamov bound, MacWilliams' identities.	18
Unit-V: Cyclic Codes Definition and examples of cyclic codes, Generator polynomial and check polynomial, Generator matrix and check matrix, Bose-Chaudhuri-Hocquenghem (BCH) code as a cyclic code.	18

References:

1. Robert B. Ash, (2014). Information Theory. Dover Publications, **(Textbook).**
2. Thomas M. Cover & Joy A. Thomas (2013). Elements of Information Theory (2nd edition). Wiley India Pvt. Ltd, **(Textbook).**
3. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition), Cengage.
4. Fazlollah M. Reza, (2003). An Introduction to Information Theory. Dover Publications.
5. Ron M. Roth (2007). Introduction to Coding Theory. Cambridge University Press.
6. Claude E. Shannon & Warren Weaver (1969). The Mathematical Theory of Communication. The University of Illinios Press.

<table>
<tr><td colspan="2">Course No: 29</td><td colspan="4">Course Name: Graph Theory</td><td colspan="4">Course Code: SBSMAT 03 05 06 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2" colspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="9">The objective of the course is to introduce students with the fundamental concepts of graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">After going through this course the students will be able to
Appreciate the definition and basics of graphs along with types and their examples.
Understand the definition of a tree and learn its applications to fundamental circuits.
Know the applications of graph theory to network flows.
Understand the notion of planarity and coloring of a graph.
Relate the graph theory to the real-world problems.</td></tr>
<tr><td colspan="9">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="9">Unit-I: Paths, Circuits and Graph Isomorphisms
Definition and examples of a graph, Subgraph, Walks, Paths and circuits; Connected graphs, disconnected graphs and components of a graph; Euler and Hamiltonian graphs, Graph isomorphisms, Adjacency matrix and incidence matrix of a graph, Directed graphs and their elementary properties.</td><td>18</td></tr>
<tr><td colspan="9">Unit-II: Trees and Fundamental Circuits
Definition and properties of trees, Rooted and binary trees, Cayley’s theorem on a counting tree, Spanning tree, Fundamental circuits, Minimal spanning trees in a connected graph.</td><td>18</td></tr>
<tr><td colspan="9">Unit-III: Cut-Sets and Cut-Vertices
Cut-set of a graph and its properties, Fundamental circuits and cut-sets, Cut-vertices, Connectivity and separability, Network flows, 1- isomorphism and 2- isomorphism.</td><td>18</td></tr>
</table>

Unit-IV: Planar Graphs Planar graph, Euler theorem for a planar graph, Various representations of a planar graph, Dual of a planar graph, Detection of planarity, Kuratowski's theorem.	18
Unit-V: Graph Coloring Chromatic number of a graph, Chromatic partition, Chromatic polynomial, Matching and coverings, Four color problem.	18

References:

1. R. Balakrishnan & K. Ranganathan (2012). A Textbook of Graph Theory. Springer, **(Textbook).**
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson, **(Textbook).**
3. Narsingh Deo (2016). Graph Theory with Applications to Engineering and Computer Science. Dover Publications.
4. Reinhard Diestel (2017). Graph Theory (5th edition). Springer.
5. Douglas West (2017). Introduction to Graph Theory (2nd edition). Pearson.

<table>
<tr><td>Course No: 30</td><td colspan="3">Course Name:
Special Theory of Relativity</td><td colspan="5">Course Code: SBSMAT 03 05 07 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The course provides a comprehensive introduction to the general theory of relativity where all forms of gravity can be described as a purely geometric effect where the curvature of space and time follows the distribution of energy and the amount momentum the matter has. An overview is given of the classical tests of theory, and how the theory is used to describe black holes, gravitational waves, and the cosmological evolution of the universe. The course also provides an introduction to differential geometry, which is necessary to be able to both formulate and apply the theory.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the basic elements of Newtonian mechanics including Michelson-Morley experiment and geometrical interpretations of Lorentz transformation equations.
Learn about length contraction, time dilation and Lorentz contraction factor.
Study 4-dimensional Minkowskian space-time and its consequences.
Understand equations of motion as a part of relativistic mechanics.
Imbibe connections between relativistic mechanics and electromagnetism.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Newtonian Mechanics
Inertial frames, Speed of light and Gallilean relativity, Michelson-Morley experiment, Lorentz-Fitzgerold contraction hypothesis, Relative character of space and time, Postulates of special theory of relativity, Lorentz transformation equations and its geometrical interpretation, Group properties of Lorentz transformations.</td><td>18</td></tr>
</table>

Unit-II: Relativistic Kinematics Composition of parallel velocities, Length contraction, Time dilation, Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor.	18
Unit-III: Geometrical representation of space-time Four dimensional Minkowskian space-time of special relativity, Time-like, light-like and space-like intervals, Null cone, Proper time, World line of a particle, Four vectors and tensors in Minkowiskian space-time.	18
Unit-IV: Relativistic Mechanics Variation of mass with velocity. Equivalence of mass and energy. Transformation equations for mass momentum and energy. Energy-momentum four vector. Relativistic force and Transformation equations for its components. Relativistic equations of motion of a particle.	18
Unit-V: Electromagnetism Transformation equations for the densities of electric charge and current. Transformation equations for electric and magnetic field strengths. The Field of a Uniformly Moving Point charge. Forces and fields near a current carrying wire. Forces between moving charges. The invariance of Maxwell`s equations.	18

References:

1. James L. Anderson (1973). Principles of Relativity Physics. Academic Press, **(Textbook).**
2. Robert Resnick (2007). Introduction to Special Relativity. Wiley**, (Textbook).**
3. Peter Gabriel Bergmann (1976). Introduction to the Theory of Relativity. Dover Publications.
4. C. Moller (1972). The Theory of Relativity (2nd edition). Oxford University Press.
5. Wolfgang Rindler (1977). Essential Relativity: Special, General, and Cosmological. Springer-Verlag.
6. V. A. Ugarov (1979). Special Theory of Relativity. Mir Publishers, Moscow.

SEMESTER – VI

Course/Paper Code	Course/Paper Title	Contact Hrs/week	Maximum Marks			
			End-Term Exam	Internal Assessment	Lab	Total Marks
SBSMAT 03 06 01 C 5106	Complex Analysis	6	105	45	-	150
SBSMAT 03 06 02 C 4046	Numerical Analysis	4	70	30	-	100
SBSMAT 03 06 02 C 4046	Numerical Analysis (Lab)	4			50	50
DSE3		6	105	45	-	150
DSE4		6	105	45	-	150
Total marks of Semester-VI						600

<table>
<tr><td>Course No: 31</td><td colspan="5">Course Name: Complex Analysis</td><td colspan="3">Course Code: SBSMAT 03 06 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">To providing the basic knowledge and to finds basic ideas of analysis for complex functions in complex variables with visualization through relevant practical’s. Particular emphasis has been laid on Cauchy’s theorems and series expansions.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere.
Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.
Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
Apply Liouville’s theorem in fundamental theorem of algebra.
Understand the convergence, term by term integration and differentiation of a power series.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Complex Plane and functions.
Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Analytic Functions and Cauchy-Riemann Equations
Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.</td><td>18</td></tr>
</table>

Unit-III: Cauchy's Theorems and Fundamental Theorem of Algebra Line integral, Path independence, Complex integration, Green's theorem, Anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula, Cauchy's inequality, Derivative of analytic function, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem and its consequences.	18
Unit-IV: Power Series Sequences, series and their convergence, Taylor series and Laurent series of analytic functions, Power series, Radius of convergence, Integration and differentiation of power series, Absolute and uniform convergence of power series.	18
Unit-V: Singularities and Contour Integration Meromorphic functions, Zeros and poles of meromorphic functions, Nature of singularities, Picard's theorem, Residues, Cauchy's residue theorem, Argument principle, Rouche's theor- em, Jordan's lemma, Evaluation of proper and improper integrals.	18

References:

1. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (9th edition). McGraw-Hill Education, **(Textbook).**
2. John B. Conway (1973). Functions of One Complex Variable. Springer-Verlag, **(Textbook).**
3. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
4. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
5. E.T. Copson (1970). Introduction to Theory of Functions of Complex Variable. Oxford University Press.
6. Theodore W. Gamelin (2001). Complex Analysis. Springer-Verlag.
7. George Polya & Gordon Latta (1974). Complex Variables. Wiley.
8. H. A. Priestley (2003). Introduction to Complex Analysis. Oxford University Press.
9. E. C. Titchmarsh (1976). Theory of Functions (2nd edition). Oxford University Press.

<table>
<tr><td>Course No: 32</td><td colspan="3">Course Name: Numerical Analysis</td><td colspan="5">Course Code: SBSMAT 03 06 02 C 4046</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem:VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td colspan="2">Total Hours: 120</td></tr>
<tr><td>Course Objective</td><td colspan="8">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Obtain numerical solutions of algebraic and transcendental equations.
Find numerical solutions of system of linear equations and check the accuracy of the solutions.
Learn about various interpolating and extrapolating methods.
Solve initial and boundary value problems in differential equations using numerical methods.
Apply various numerical methods in real life problems.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Numerical Methods for Solving Algebraic and Transcendental Equations
Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.</td><td>24</td></tr>
<tr><td colspan="8">Unit-II: Numerical Methods for Solving Linear Systems
Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a</td><td>24</td></tr>
</table>

matrix and its applications, Thomas method for tridiagonal systems; Gauss-Jacobi, Gauss-Seidel and successive over-relaxation (SOR) methods.	
Unit-III: Interpolation Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory-Newton forward and backward difference interpolations.	24
Unit-IV: Numerical Differentiation and Integration First order and higher order approximation for first derivative, Approximation for second derivative; Numerical integration: Trapezoidal rule, Simpson's rules and error analysis, Bulirsch-Stoer extrapolation methods, Richardson extrapolation.	24
Unit-V: Initial and Boundary Value Problems of Differential Equations Euler's method, Runge-Kutta methods, Higher order one step method, Multi-step methods; Finite difference method, Shooting method, Real life examples: Google search engine, 1D simulations, Weather forecasting.	24

References:

1. R. K. Gupta, Numerical methods: Fundamental and Applications, 1st Edition, Cambridge University Press, **(Textbook).**
2. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers, **(Textbook).**
3. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
4. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.
5. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.
6. Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

<table>
<tr><td>Course No: 33</td><td colspan="3">Course Name: Discrete Mathematics</td><td colspan="5">Course Code: SBSMAT 03 06 01 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations, trees and graphs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Learn about partially ordered sets, lattices and their types.
Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.
Solve real-life problems using finite-state and Turing machines.
Assimilate various graph theoretic concepts and familiarize with their applications.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Partially Ordered Sets
Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Lattices
Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.</td><td>18</td></tr>
</table>

Unit-III: Boolean Algebras and Switching Circuits Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive and conjunctive normal forms, Minimal forms of Boolean polynomials, Quine-McCluskey method, Karnaugh diagrams, Switching circuits and applications.	18
Unit-IV: Finite-State and Turing Machines Finite-state machines with outputs, and with no output; Deterministic and nodeterministic finite-state automaton; Turing machines: Definition, examples, and computations.	18
Unit-V: Basic of Graphs Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling- salesman problem, Shortest path and Dijkstra's algorithm.	18

References:

1. Kenneth H. Rosen (2012). Discrete Mathematics and its Applications: With Combinatorics and Graph Theory (7th edition). McGraw-Hill, **(Textbook).**
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education, **(Textbook).**
3. B. A. Davey & H. A. Priestley (2002). Introduction to Lattices and Order (2nd edition). Cambridge University Press.
4. Rudolf Lidl & Günter Pilz (1998). Applied Abstract Algebra (2nd edition). Springer.
5. C. L. Liu (1985). Elements of Discrete Mathematics (2nd edition). McGraw-Hill.

<table>
<tr><td>Course No: 34</td><td colspan="4">Course Name: Wavelets and Applications</td><td colspan="4">Course Code: SBSMAT 03 06 02 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">Most students today have had experience downloading compressed image or sound files from the web, or using software such as Adobe Photoshop to enhance a photo they have taken, or watching a crime solving drama where the fingerprints of a perpetrator are compared against those stored in AFIS. This course uses mathematical theory, recently developed applications, and computation to introduce students to the basics of the enhancement and compression of digital image and sound files. Students from mathematics, physics, and computer science might benefit from such a course.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Know basic concepts of signals and systems.
• Understand the concept of Haar spaces.
• Learn Fourier transform and wavelet transform of digital signals.
• Learn applications of wavelets to the real-world problems.
• Apply wavelets in signal processing and image processing.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I: Signals and Systems
Basic concepts of signals and systems, Frequency spectrum of signals; Classification of signals: Discrete time signals and continuous time signals, periodic and non-periodic signals; Classification of systems: Linear, nonlinear, time-variant, time-invariant, stable and unstable systems.</td><td colspan="2">18</td></tr>
<tr><td colspan="7">Unit-II: Haar Scaling Function and Wavelet, Time-Frequency Analysis
Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions, Haar scaling function, Haar spaces: Haar space VO, general Haar space Vj; Haar wavelet,</td><td colspan="2">18</td></tr>
</table>

Haar wavelet spaces: Haar wavelet space WO, general Haar wavelet space Wj; Decomposition and reconstruction, Time-frequency analysis, Orthogonal and orthonormal bases.	
Unit–III: Fourier Transforms and Wavelets Discrete Fourier transform of a digital signal, Complex form of a Fourier series, Inverse discrete Fourier transform, Window Fourier transform, Short time Fourier transform, Admissibility condition for a wavelet, Classes of wavelets: Haar, Morlet, Maxican hat, Meyer and Daubechies wavelets; Wavelets with compact support.	18
Unit–IV: Discrete Wavelet Transforms Stationary and non-stationary signals, Haar transform, 1-level Haar transform, Multi-level Haar transform, Conservation and compaction of energy, Multiresolution analysis, Decomposition and reconstruction of signals using discrete wavelet transform (DWT).	18
Unit–V: Applications Wavelet series expansion using Haar and other wavelets, Applications in signal compression, Analysis and classification of audio signals using DWT, Signal de-noising: Image and ECG signals.	18

References:

1. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press, **(Textbook).**
2. David K. Ruch & Patrick J. Van Fleet (2009), Wavelet Theory: An Elementary Approach with Applications. John Wiley & Sons, **(Textbook).**
3. Ingrid Daubechies (1999). Ten Lectures on Wavelets. SIAM
4. Michael W. Frazier (1999). An Introduction to Wavelets Through Linear Algebra. Springer-Verlag.
5. Stéphane Mallat (2008). A Wavelet Tour of Signal Processing (3rd edition). Academic Press.
6. M.J. Roberts (2004). Signals and Systems: Analysis Using Transform Methods and MATLAB. McGraw-Hill Education.
7. James S. Walker (2008). A Primer on Wavelets and Their Scientific Applications (2nd edition). Chapman & Hall/CRC, Taylor & Francis.

<table>
<tr><td>Course No: 35</td><td colspan="3">Course Name: Number Theory</td><td colspan="5">Course Code: SBSMAT 03 06 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is aimed at undergraduate mathematics majors. It is a first course in number theory, and is intended to introduce students to number theoretic problems and to different areas of number theory. Number theory has a very long history compared to some other areas of mathematics, and has many applications, especially to coding theory and cryptography.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Wilson's theorem and their consequences.
Learn about number theoretic functions, modular arithmetic and their applications.
Familiarize with modular arithmetic and find primitive roots of prime and composite numbers.
Know about open problems in number theory, namely, the Goldbach conjecture and twin-prime conjecture.
Apply public crypto systems, in particular, RSA.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Distribution of Primes and Theory of Congruencies
Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Twin-prime conjecture, Odd perfect numbers conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Number Theoretic Functions
Number theoretic functions for sum and number of divisors, Multiplicative function, The</td><td>18</td></tr>
</table>

Möbius inversion formula, Greatest integer function, Euler's phi-function and properties, Euler's theorem.	
Unit-III: Primitive Roots Order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, Euler's criterion.	18
Unit-IV: Quadratic Reciprocity Law The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli.	18
Unit-V: Applications Public key encryption, RSA encryption and decryption with applications in security systems.	18

References:

1. David M. Burton (2007). Elementary Number Theory (7th edition). McGraw-Hill, **(Textbook).**
2. Neville Robbins (2007). Beginning Number Theory (2nd edition). Narosa, **(Textbook).**
3. Gareth A. Jones & J. Mary Jones (2005). Elementary Number Theory. Springer.
4. I.Niven (2012). An Introduction to the Theory of Numbers (5th edition). John Wiley & Sons.
5. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag.

<table>
<tr><td>Course No: 36</td><td colspan="4">Course Name: Mathematical Finance</td><td colspan="4">Course Code: SBSMAT 03 06 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course provides an introduction to the basic mathematical concepts and techniques used in finance and business, highlighting the inter-relationships of the mathematics and developing problem solving skills with a particular emphasis on financial and business applications..</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Understand financial markets and derivatives including options and futures.
• Appreciate pricing and hedging of options, interest rate swaps and no-arbitrage pricing concepts.
• Learn stochastic analysis, Ito's formula, Ito integral and the Black−Scholes model.
• Study and use Hedging parameters, trading strategies and currency swaps.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Unit-I: Basic Theory of Interest and Fixed-Income Securities
Principal and interest: simple, compound and continuous; Present and future value of cash flow streams; Net present value, Internal rates of return and their comparison; Inflation, Annuities; Bonds, Bond prices and yields, Macaulay duration and modified duration.</td><td colspan="2">18</td></tr>
<tr><td colspan="7">Unit-II: Term Structure of Interest Rates, Bonds and Derivatives
Spot rates, forward rates and explanations of term structure; Running present value, Floating- rate bonds, Immunization, Convexity; Putable and callable bonds; Exchange-traded markets and over-the-counter markets; Derivatives: Forward contracts, Future contracts, Options, Types of traders, Hedging, Speculation, Arbitrage.</td><td colspan="2">18</td></tr>
</table>

Unit-III: Mechanics of Options Markets No-arbitrage principle, Short selling, Forward price for an investment asset; Types of options: Call and put options, Option positions, Underlying assets, Factors affecting option prices, Upper and lower bounds for option prices, Put-call parity, Effect of dividends.	18
Unit-IV: Stochastic Analysis of Stock Prices and Black-Scholes Model Binomial option pricing model, Risk neutral valuation: European and American options on assets following binomial tree model; Lognormal property of stock prices, Distribution of rate of return, Expected return, Volatility, Estimating volatility from historical data, Extension of risk-neutral valuation to assets following geometric Brownian motion, Black-Scholes formula for European options.	18
Unit-V: Hedging Parameters, Trading Strategies and Swaps Hedging parameters: Delta, gamma, theta, rho and vega; Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swaps, Currency swaps, Valuation of currency swaps.	18

References:

1. John C. Hull & Sankarshan Basu (2018). Options, Futures and Other Derivatives (10th edition). Pearson Education, **(Textbook).**
2. David G. Luenberger (2013). Investment Science (2nd edition). Oxford University Press.
3. Sheldon M. Ross (2011). An Elementary Introduction to Mathematical Finance (3rd edition). Cambridge University Press.

<table>
<tr><td>Course No: 37</td><td colspan="3">Course Name: Cryptography</td><td colspan="5">Course Code: SBSMAT 03 06 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">Cryptography is the practice and study of techniques for securing communications in the presence of third parties. This course aims to impart knowledge and protect information in order to ensure its integrity, confidentiality, authenticity, and non-repudiation. This course gives with a basic understanding of cryptographic concepts and how to apply them, implement secure protocols, key management concepts, key administration and validation, and Public Key Infrastructure.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the difference between classical and modern cryptography.
Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards (DES & AES) and RSA.
Encrypt and decrypt messages using block ciphers, sign and verify messages using well-known signature generation and verification algorithms.
Know about the aspects of number theory which are relevant to cryptography.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit I: Introduction to Cryptography and Classical Cryptography
Cryptosystems and basic cryptographic tools: Secret-key cryptosystems, Public-key cryptosystems, Block and stream ciphers, Hybrid cryptography, Message integrity: Message authentication codes, Signature schemes, Nonrepudiation, Certificates, Hash functions, Cryptographic protocols, Security; Hybrid cryptography: Message integrity, Cryptographic protocols, Security, Some simple cryptosystems, Shift cipher, Substitution cipher, Affine cipher, Vigenère cipher, Hill cipher, Permutation cipher, Stream ciphers, Cryptanalysis of affine, substitution, Vigenère, Hill and LFSR stream ciphers.</td><td>18</td></tr>
</table>

Unit-II: Cryptographic Security, Pseudo Randomness and Symmetric Key Ciphers Shannon's theory, Perfect secrecy, Entropy, Spurious keys and unicity distance; Bit generators, Security of pseudorandom bit generators. Substitution-permutation networks, Data encryption standard (DES), Description and analysis of DES; Advanced encryption standard (AES), Description and analysis of AES; Stream ciphers, Trivium.	18
Unit-III: Basics of Number Theory and Public-Key Cryptography Basics of number theory; Introduction to public-key cryptography, RSA cryptosystem, Implementing RSA; Primality testing, Legendre and Jacobi symbols, Solovay-Strassen algorithm, Miller-Rabin algorithm; Square roots modulo n, Factoring algorithms, Pollard P - 1 algorithm, Pollard rho algorithm, Dixon's random squares algorithm, Factoring algorithms in practice; Rabin cryptosystem and its security.	18
Unit-IV: More on Public-Key Cryptography Basics of finite fields; ElGamal cryptosystem, Algorithms for the discrete logarithm problem, Shanks' algorithm, Pollard rho discrete logarithm algorithm, Pohlig-Hellman algorithm; Discrete logarithm algorithms in practice, Security of ElGamal systems, Bit security of discrete logarithms.	18
Unit-V: Hash Functions and Signature Schemes Hash functions and data integrity, SHA-3; RSA signature scheme, Security requirements for signature schemes, Signatures and Hash functions, ElGamal signature scheme, Security of ElGamal signature scheme, Certificates.	18

References:

1. Jeffrey Hoffstein, Jill Pipher & Joseph H. Silverman (2014). An Introduction to Mathematical Cryptography (2nd edition). Springer, **(Textbook).**
2. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag, **(Textbook).**
3. Christof Paar & Jan Pelzl (2014). Understanding Cryptography. Springer.
4. Simon Rubinstein-Salzedo (2018). Cryptography. Springer.
5. Douglas R. Stinson & Maura B. Paterson (2019). Cryptography Theory and Practice (4th edition). Chapman & Hall/CRC Press, Taylor & Francis.

<table>
<tr><td>Course No: 38</td><td colspan="3">Course Name: Advanced Mechanics</td><td colspan="5">Course Code: SBSMAT 03 06 06 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">In this course, students will be imparted knowledge to enable them to understand several concepts of Advanced Mechanics such as Central axis, Wrench, Impulsive motion, Streamlines, pathlines, Moments and products of inertia.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the reduction of force system in three dimensions to a resultant force acting at a base point and a resultant couple, which is independent of the choice of base of reduction.
Learn about a null point, a null line, and a null plane with respect to a system of forces acting on a rigid body together with the idea of central axis.
Know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia and to derive Euler's equations of motion of a rigid body, moving about a point which is kept fixed.
Study the kinematics and kinetics of fluid motions to understand the equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates which are used to derive Euler's equations and Bernoulli's equation.
Deal with two-dimensional fluid motion using the complex potential and also to understand the concepts of sources, sinks, doublets and the image systems of these with regard to a line and a circle.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I: Statics in Space
Forces in three dimensions, Reduction to a force and a couple, Equilibrium of a system of particles, Central axis and Wrench, Equation of the central axis, Resultant wrench of two wrenches; Null points, lines and planes with respect to a system of forces, Conjugate forces and conjugate lines.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Motion of a Rigid Body</td><td>18</td></tr>
</table>

Moments and products of inertia of some standard bodies, Momental ellipsoid, Principal axes and moments of inertia; Motion of a rigid body with a fixed point, Kinetic energy of a rigid body with a fixed point and angular momentum of a rigid body, Euler's equations of motion for a rigid body with a fixed point, Velocity and acceleration of a moving particle in cylindrical and spherical polar coordinates, Motion about a fixed axis, Compound pendulum.	
Unit-III: Kinematics of Fluid Motion Lagrangian and Eulerian approaches, Material and convective derivatives, Velocity of a fluid at a point, Equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates, Cylindrical and spherical symmetry, Boundary surface, Streamlines and pathlines, Steady and unsteady flows, Velocity potential, Rotational and irrotational motion, Vorticity vector and vortex lines.	18
Unit-IV: Kinetics of Fluid Motion Euler's equations of motion in Cartesian, cylindrical polar and spherical polar coordinates; Bernoulli's equation, Impulsive motion.	18
Unit-V: Motion in Two-Dimensions Stream function, Complex potential, Basic singularities: Sources, sinks, doublets, complex potential due to these basic singularities; Image system of a simple source and a simple doublet with regard to a line and a circle, Milne-Thomson circle theorem.	18

References:

1. A. S. Ramsay (1960). A Treatise on Hydromechanics, Part-II Hydrodynamics. G. Bell & Sons, **(Textbook).**
2. F. Chorlton (1967). A Textbook of Fluid Dynamics. CBS Publishers, **(Textbook).**
3. Michel Rieutord (2015). Fluid Dynamics An Introduction. Springer.
4. E. A. Milne (1965). Vectorial Mechanics, Methuen & Co.Limited. London.

Course No: 39	**Course Name:** Dissertation on Any Topic of Mathematics					**Course Code:** SBSMAT 03 06 07 DSE 5106	
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:VI**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**

10. GENERIC ELECTIVE COURSES (GEC)

(Only for Other Departments)

Sr.	Course code	Course title	L	T	P	Credits
1.	SBSMAT 03 01 01 GE 5106	Introductory Calculus and Analysis	5	1	0	6
2.	SBSMAT 03 01 02 GE 5106	Basic Mathematics for Social Sciences	5	1	0	6
3.	SBSMAT 03 01 03 GE 5106	Probability and Statistics	5	1	0	6
4.	SBSMAT 03 02 01 GE 5106	Vector Calculus	5	1	0	6
5.	SBSMAT 03 02 02 GE 5106	Mathematics for Chemists	5	1	0	6
6.	SBSMAT 03 02 03 GE 5106	Numerical Methods	5	1	0	6
7.	SBSMAT 03 03 01 GE 5106	Linear Algebra	5	1	0	6
8.	SBSMAT 03 03 02 GE 5106	Differential Equations	5	1	0	6
9.	SBSMAT 03 03 03 GE 5106	Complex Analysis	5	1	0	6
10.	SBSMAT 03 04 01 GE 5106	Introduction to Graph Theory	5	1	0	6
11.	SBSMAT 03 04 02 GE 5106	Optimization Techniques	5	1	0	6
12.	SBSMAT 03 04 03 GE 4046	Mathematical Modelling	5	1	0	6

Note: Any course from MOOCs for PG students on SWAYAM can also be taken as DSEC or GEC course on recommendations of the department.

<table>
<tr><td>Course No: 01</td><td colspan="3">Course Name:
Introductory Calculus and Analysis</td><td colspan="5">Course Code: SBSMAT 03 01 01 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce basic structures of mathematics like limit, continuity, differentiability integration, sequence, and series. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
Calculate the limit and examine the continuity of a function at a point.
Understand the consequences of various mean value theorems for differentiable functions.
Understand the integration and their applications.</td></tr>
</table>

Content of Each Unit	Hours
Unit I: Successive differentiation and Leibnitz theorem, limits, continuity, and differentiability, Mean value theorem, Taylors Theorem, Maxima and Minima.	18
Unit-II: Riemann integration, Darboux theorem, Fundamental theorem of integral Calculus, Improper integrals, Beta function, Gamma functions and related definite integrals. Surface area and Volume.	18
Unit-III: Convergence of sequences and series, power series.	18
Unit-IV: Partial differentiation, Euler’s theorem and chain rule. Directional derivatives and gradients, maxima and minima, Lagrange multipliers.	18

Unit-V: Double and Triple integration, Jacobians and change of variables. Parametrization of curves and surfaces, vector Fields, line and surface integrals. Divergence and curl, Theorems of Green, Gauss, and Stokes.	18

References:

1. M. D. Weir, J. Hass and F. R. Giordano: *Thomas' Calculus*, 11th edition, Pearson, 2008 **(Textbook).**
2. T. M. Apostol: *Calculus*, *Volumes 1 and 2*, 2nd edition, Wiley, 1980.
3. J. Stewart: *Calculus*, 5th edition, Thomson, 2003.
4. N. Piskunov: Differential and Integral Calculus, Mir Publishers, 1969.
5. S. Narayan: A Textbook of Vector Calculus, S. Chand, 2003.

<table>
<tr><td>Course No: 02</td><td colspan="3">Course Name: Basic Mathematics for Social Sciences</td><td colspan="5">Course Code: SBSMAT 03 01 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The main objective of this course is to encourage students to develop a working knowledge of the basic Mathematics for social science and will present some of the ideas that form the foundation of quantitative work in the social sciences. In particular, topics from logarithm, set theory, matrix theory and calculus will be discussed with emphasis on the understanding ofconcepts and the development of intuition.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Explain the fundamental concepts of indices, logarithm and antilogarithm and their role in basic Mathematics for social science.
• Demonstrate accurate and efficient use of set theory and Venn diagram.
• Understand and use the terms: function, relation, series arithmetic, geometric progression, Permutations and Combinations.
• Understand the concepts and properties of limits, continuity and differentiation of a function, logical reasoning, probability and descriptive statistics</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I
Binary numbers, indices, logarithm and antilogarithm, laws and properties of logarithms, simple applications of logarithm and antilogarithm, numerical problems on averages, calendar, clock, time, work and distance, mensuration, seating arrangement, sets, types of sets, Venn diagram, De Morgan's laws, problem solving using Venn diagram, relations and types of relations.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II
Introduction of sequences, series arithmetic and geometric progression, relationship between AM and GM. Basic concepts of permutations and combinations, permutations, combinations with standard results. Introducing functions, domain and range of a function, types of functions (Polynomial function; Rational function; Logarithm function, Exponential function; Modulus function; Greatest Integer function, Signum</td><td>18</td></tr>
</table>

function), Graphical representation of functions.	
Unit-III Concept of limits and continuity of a function, instantaneous rates of change, differentiation as a process of finding derivative, derivatives of algebraic functions using Chain rule. Mathematically acceptable statements, connecting words/ phrases in Mathematical statement consolidating the understanding of "if and only if (necessary and sufficient) condition", "implies", "and/or", "implied by", "and", "or", "there exists" and their use through variety of examples related to real life and Mathematics problems based on logical reasoning (coding-decoding, odd man out, blood, relation, syllogism etc).	18
Unit-IV Random experiment, sample space, events, mutually exclusive events. Independent and dependent Events, law of total probability, Bayes' Theorem.	18
Unit-V Data on various scales (nominal, ordinal, interval and ratio scale), data representation and visualization, data interpretation (dispersion, deviation, variance, skewness and kurtosis), percentile rank and quartile rank, correlation (Pearson and Spearman method of correlation), applications of descriptive statistics using real time data.	18

References:

1. Gill J. Essential Mathematics for Political and Social Research, Cambridge University Press, 2016 **(Textbook).**
2. Haeussler E., Paul R. and Wood R. Introductory Mathematical Analysis for Business, Economics, and the Life and Social Sciences, 15th edition. Prentice-Hall, 2015.
3. Goldstein L., Lay D., and Schneider D. Calculus and Its Applications, 14th Edition. Prentice Hall, 2014.
4. Hagle T. Basic Math for Social Scientists: Problems and Solutions, 1996.
5. Hagle T. Basic Math for Social Scientists: Concepts, 1996.
6. Kleppner D. and Ramsey N. Quick Calculus. Wiley, 1995.

<table>
<tr><td>Course No: 03</td><td colspan="4">Course Name: Probability and Statistics</td><td colspan="3">Course Code: SBSMAT 03 01 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses. After taking this course, students will be able to use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB, to perform simple and sophisticated analyses for large samples.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand distributions in the study of the joint behaviour of two random variables.
• Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
• Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.</td></tr>
</table>

Content of Each Unit	**Hours**
Unit-I: Probability Functions and Moment Generating Function Basic notions of probability, Conditional probability and independence, Baye’s theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.	18
Unit-II: Univariate Discrete and Continuous Distributions Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.	18

Unit-III: Bivariate Distribution Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.	18
Unit-IV: Correlation, Regression and Central Limit Theorem The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.	18
Unit-V: Modeling Uncertainty Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.	18

References:

1. Irwin Miller & Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India, **(Textbook).**
2. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.
6. V.K. Kapoor and S. C. Gupta (2018). Fundamental of Mathematical Statistics, S. Chand & Sons.

Course No: 04	Course Name: Vector Calculus	Course Code: SBSMAT 03 02 01 GE 5106

Batch:	Program: UG	Sem: II	L	T	P	Credits	Contact Hrs per Week: 06
			5	1	0	6	Total Hours: 90

Course Objective	The course provides an introduction to functions of several real variables and classical vector analysis. Topics discussed are: partial derivatives, gradients, line and surface integrals; vector valued functions, divergence, curl and flux of vector fields, the theorems of Green and Stokes, the divergence theorem, and applications
Course Outcomes	After going through this course the students will be able to • Find the Triple product of Products and their Applications • Understand the concept of Line integral and Surface integral • Understand the concept of Tensor

Content of Each Unit	Hours
Unit I Vectors, Scalars and Dot Product, Triple Products, Scalar and Vector Fields, Methods of Integration and Examples,	18
Unit-II: Line Integrals, Surface and Volume Integrals with Examples, Partial Differentiation, Taylor Series and Gradients, Divergence, Laplacian and Curl	18
Unit-III: Suffix Notation, Kronecker Delta and Alternating Tensor and Review, Relations Among and Properties of Vector and Tensor Operations, Gauss' Divergence Theorem and Applications, Stokes' Theorem and Applications, More on Gauss' and Stokes' Theorems	18
Unit-IV: Curvilinear Coordinates, Gradient, Divergence and Curl in Curvilinear Coordinates, Examples in Cylindrical and Spherical Coordinates	18
Unit-V: Tensors and Applications and Review, Tensors and Applications, Physical Applications of Tensors, Applications	18

References:

1. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas Calculus, 13/e, Pearson Publishers, 2013, (**Textbook**).
2. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, 3/e, Alpha Science International Ltd., 2002.
3. Michael Greenberg, Advanced Engineering Mathematics, 2/e, Pearson, 2018.

<table>
<tr><td>Course No: 05</td><td colspan="3">Course Name: Mathematics for Chemists</td><td colspan="5">Course Code: SBSMAT 03 02 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The main objective of this course is to introduce the students to the exciting world of numerical analysis, differential equations and statistics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After completing this course, student is expected to learn the following:
• Learn the basics of numerical analysis, to calculate the errors in approximations and their properties.
• Understand the basics of differential equations to solve the first order linear differential equations and second order differential equations.
• Analyze the singular points, power series solution of differential equation at regular and irregular singular points, Bessel’s and Legendre’s equations and their solutions.
• Use the basics tools of statistics and by using these techniques to measures central tendency, learn Gaussian and Binomial distributions.</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit-I
Algebraic, transcendental functions, approximation, errors in approximation, absolute, relative and percentage errors, matrices and their properties, some special matrices, matrix algebra, the inverse matrix, linear transformations, orthogonal matrices and orthogonal transformations.</td><td>15</td></tr>
<tr><td colspan="8">Unit-II
Solution of differential equations, first-order linear equations- separable equations, homogeneous linear equations, non-homogeneous linear equations, second-order differential equations with constant coefficients, general solution, particular solution, linear equations in chemical kinetics, harmonic oscillator and
some other applications</td><td>15</td></tr>
</table>

Unit-III Singular points, power series solution of differential equation at regular and irregular singular points, Bessel's and Legendre's equations and their solutions, partial differentiation, types of partial differential equations.	15
Unit-IV Line integrals, double integrals, change of variables, polar coordinates, volume integrals, Laplacian operator, finite difference operators.	
Unit-V Descriptive statistics, measures of central tendency, measures of dispersion, frequency and probability, permutations and combinations, binomial distribution, Gaussian distribution.	15

References:

1. Steiner, E. The Chemistry Maths Book. 2nd edition, Oxford University Press, 2008, **(Textbook).**
2. Gupta, S. C. and Kapoor, V.K. Fundamentals of Mathematical Statistics. S. Chand & Sons, 2014.
3. Lipschutz, S. and Lipson, M. Linear Algebra. 3rd edition, Tata McGraw-Hill, 2005.
4. Raisinghania, M. D. Advanced Differential Equations. S. Chand & Company Ltd. New Delhi, 2001.

<table>
<tr><td colspan="2">Course No: 06</td><td colspan="3">Course Name: Numerical Methods</td><td colspan="4">Course Code: SBSMAT 03 02 03 GE 3104</td></tr>
<tr><td rowspan="2">Batch:</td><td colspan="2" rowspan="2">Program: UG</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems
Find the Numerical solutions of Non-linear equations
Familiarize the students with advantages and limitations of numerical techniques
Solve interpolation problems, difference equations and Eigen value problems</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit I Nature of numerical computations: errors and their propagation</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Numerical solution of systems of linear equations: Direct methods for solving linear systems, error analysis. The residual correction method. Iteration methods, Error prediction and Acceleration.</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Matrix Eigenvalue problem: Eigenvalue location, error, and stability results, Power method. Orthogonal transformations using Householder matrices. The eigenvalues of a symmetric Tridiagonal matrix. QR method. The calculation of Eigenvectors and Inverse iteration.</td><td>18</td></tr>
</table>

Unit-IV: Numerical solutions of Non-linear equations: Solution of non-linear equations by iterative methods, acceleration of convergence. Newton's methods for polynomials, quotient-difference algorithms. Numerical solution of system of Non-linear equations.	18
Unit-V: Interpolation: Interpolating polynomial and its construction using Lagrange methods and methods of differences, iterated interpolation, method of divided differences, inverse interpolation, Hermite Interpolation. The general Hermite interpolation problem. Spline function and their use.	18

References:

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.
2. R.L. Burden and J.D. Faires: Numerical analysis, 7th edition, Brooks Cole, 2001.
3. P.J. Davis: Interpolation and Approximation, Dover, 1975.
4. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.
5. S.S. Sastry: Introductory Methods of Numerical Analysis, Phi Learning, 2009.

Lab Component: Exposure to MATLAB/Mathematica and computational experiments based on the algorithms discussed in the course.

Course No: 07	Course Name: Linear Algebra					Course Code: SBSMAT 03 03 01 GE 5106	
Batch:	**Program: UG**	**Sem: III**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The objective of the course is to develop the understanding about some basic concepts of Linear Algebra.						
Course Outcomes	After going through this course the students will be able to • Describe the concepts of the terms basis, dimension, and apply these concepts to various vector spaces and subspaces • Use the concept of linear transformations, matrix representation and change of basis, including kernel, range • Compute inner products and determine orthogonality on vector spaces, applying Gram-Schmidt orthogonalization process to find the orthonormal basis. • Understand the notion of algebraic, geometric multiplicities and diagonalization.						

Content of Each Unit	Hours
Unit I: Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$, notions of linear dependence and independence, linear span of a set of vectors.	18
Unit-II: Vector Space and subspaces, basis of a vector subspace.	18
Unit-III: Systems of linear equations, matrices and Gauss elimination, row space, null space, and column space, rank of a matrix. Determinants and rank of a matrix. linear transformations, matrix of a linear transformation	18
Unit-IV: Inner product in Euclidean space, Gram-Schmidt orthogonalization process, orthonormal bases, projections, and the least squares approximation.	18

Unit-V: Eigenvalues and eigenvectors, characteristic polynomials, Cayley-Hamilton theorem, the eigenvalue of special matrices (orthogonal, unitary, symmetric, Hermitian, skew-symmetric, normal). Algebraic and geometric multiplicities, diagonalization by similarity transformations.	18

References:

1. G. Strang: Linear Algebra and its Applications, 4th edition, Thomson, 2006, **(Textbook).**
2. H. Anton and C. Rorres: Elementary Linear Algebra with Applications, 9th edition, Wiley, 2005.
3. P. D. Lax: Linear Algebra and Its Applications, 2nd edition, Wiley, 2007.
4. R. A. Horn and C.R. Johnson: Matrix Analysis, Cambridge University Press, 1990.
5. P. R. Halmos: Finite-dimensional Vector Spaces, Springer, 1974.
6. C.D. Meyer: Matrix Analysis and Applied Linear Algebra, SIAM, 2000.
7. S.L. Campbell and C.D. Meyer: Generalized Inverses of Linear Transformations, SIAM, 2008.
8. A. J. Laub: Matrix Analysis for Scientists and Engineers, SIAM, 2004.
9. V. Krishnamurthy, V.P Mainra and J.L Arora: An Introduction to Linear Algebra, East-West Press, New Delhi 2011.

<table>
<tr><td>Course No: 08</td><td colspan="3">Course Name: Differential Equations</td><td colspan="5">Course Code: SBSMAT 03 03 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce ordinary differential equations, general, particular, explicit, implicit and singular solutions of a differential equation. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand the genesis of ordinary differential equations.
• Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
• Know Picard’s method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.
• Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
• Formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: First Order Differential Equations
Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, differential Equations in which variables are separable, Homogeneous differential equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree differential equations solvable for x, y and p. Clairaut’s form and singular solutions. Picard’s method of successive approximations and the</td><td>18</td></tr>
</table>

statement of Picard's theorem for the existence and uniqueness of the solutions of the first order differential equations.	
Unit-II: Second Order Linear Differential Equations Statement of existence and uniqueness theorem for linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients, Reduction of order, Coupled linear differential equations with constant coefficients.	18
Unit-III: Higher Order Linear Differential Equations Principle of superposition for a homogeneous linear differential equation, Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous differential equations of higher order with constant coefficients, Euler-Cauchy equation, Method of variation of parameters and method of undetermined coefficients, Inverse operator method.	18
Unit-IV: First Order Partial Differential Equations Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.	18
Unit-V: Second Order Partial Differential Equations with Constant Coefficients Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients.	18

References:

1. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India, **(Textbook).**
2. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley, **(Textbook).**
3. E.A. Coddington and N. Levinson (2016). Theory of Ordinary Differential Equations (18th edition), Tata McGRAW-Hill.

4. George F. Simmons (2017). Differential Equations with Applications and Historical Notes (3rd edition). CRC Press. Taylor & Francis.
5. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd edition). Narosa.

<table>
<tr><td>Course No: 09</td><td colspan="4">Course Name: Complex Analysis</td><td colspan="3">Course Code: SBSMAT 03 03 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To providing the basic knowledge and to finds basic ideas of analysis for complex functions in complex variables with visualization through relevant practical's. Particular emphasis has been laid on Cauchy's theorems and series expansions.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere.
• Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.
• Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
• Apply Liouville's theorem in fundamental theorem of algebra.
• Understand the convergence, term by term integration and differentiation of a power series.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Complex Plane and functions.
Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Analytic Functions and Cauchy-Riemann Equations
Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.</td><td>18</td></tr>
</table>

Unit-III: Cauchy's Theorems and Fundamental Theorem of Algebra Line integral, Path independence, Complex integration, Green's theorem, Anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula, Cauchy's inequality, Derivative of analytic function, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem and its consequences.	18
Unit-IV: Power Series Sequences, series and their convergence, Taylor series and Laurent series of analytic functions, Power series, Radius of convergence, Integration and differentiation of power series, Absolute and uniform convergence of power series.	18
Unit-V: Singularities and Contour Integration Meromorphic functions, Zeros and poles of meromorphic functions, Nature of singularities, Picard's theorem, Residues, Cauchy's residue theorem, Argument principle, Rouche's theor- em, Jordan's lemma, Evaluation of proper and improper integrals.	18

References:

1. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (9th edition). McGraw-Hill Education, **(Textbook).**
2. John B. Conway (1973). Functions of One Complex Variable. Springer-Verlag, **(Textbook).**
3. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
4. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
5. E.T. Copson (1970). Introduction to Theory of Functions of Complex Variable. Oxford University Press.
6. Theodore W. Gamelin (2001). Complex Analysis. Springer-Verlag.
7. George Polya & Gordon Latta (1974). Complex Variables. Wiley.
8. H. A. Priestley (2003). Introduction to Complex Analysis. Oxford University Press.
9. E. C. Titchmarsh (1976). Theory of Functions (2nd edition). Oxford University Press.

<table>
<tr><td>Course No: 10</td><td colspan="4">Course Name: Introduction to Graph Theory</td><td colspan="4">Course Code: SBSMAT 03 04 01 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objective of the course is to introduce students with the fundamental concepts graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
Understand the concept of Graphs
Use the concept of planar graphs, trees and study for their properties
Analyze Matchings and coverings in Bipartite graphs</td></tr>
<tr><td colspan="8">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Unit I Graphs and Sub graphs:- Graphs and simple graphs, Graph isomorphism, The incidence and adjacency matrices, sub graphs, connected and bipartite graphs, walk, trail, path and cycles. Application: - The Shortest path problem, Dijkstra algorithm, Warshall Algorithm.</td><td>18</td></tr>
<tr><td colspan="8">Unit-II: Trees:- Trees, Cut Edge and Bond, Cut vertex, spanning trees and Cayley's formula. The Connector Problem: Prim's Algorithm, Kruskal's Algorithm</td><td>18</td></tr>
<tr><td colspan="8">Unit-III: Euler tour and Hamilton's Cycles, characterization of Eulerian graphs, a necessary and some sufficient characterizations of Hamiltonian graph. Closure and degree majorization and related results, Chinese Postman Problem</td><td>18</td></tr>
<tr><td colspan="8">Unit-IV: Matchings: Theorem of Berge, Matchings and coverings in Bipartite graphs, Application: Hall's marriage theorem, Some Assignment Problems.</td><td>18</td></tr>
<tr><td colspan="8">Unit-V:
Application of Graphs.
Lab Component: Implementation in C: Dijkstra Algorithm, Warshall Algorithm, BFS, DFS, Prims Algorithm, Kruskal Algorithm, Connectivity Algorithm, Flurey Algorithm.</td><td>18</td></tr>
</table>

References:

1. J.A. Bondy and U.S.R Murty: Graph Theory, Springer, 2008, **(Textbook).**
2. F. Harary: Graph Theory, Westview Press, 1994, **(Textbook).**.
3. R.J. Wilson: Introduction to Graph Theory, 4^{th} edition, Pearson, 2002.
4. J. Clark and D. A. Holton: A First Look at Graph Theory, World Scientific, 1991.
5. D.B. West: Introduction to Graph Theory, 2^{nd} edition, PHI Learning, 2009.
6. N. Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India, 2004

<table>
<tr><td>Course No: 11</td><td colspan="3">Course Name: Optimization Techniques</td><td colspan="5">Course Code: SBSMAT 03 04 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Understand linear programming problems and to find their solutions by using different method.
• Use the simplex method to solve linear programming
• Solve the Dual of Linear Programing problem
• Find optimal solution of transportation problems and assignment problems</td></tr>
</table>

Content of Each Unit	**Hours of Each Unit**
Unit I Introduction to Operation Research: Operations research techniques, simulation models. Convex Sets and Convex functions.	18
Unit-II: Linear Programming formulation and graphical solution: Models of mathematical operations research, art of modeling, construction of the LP model, graphical LP solution.	18
Unit-III: The Simplex method: Standard LP form, basic solution, The Simplex method, the M-method, the two-phase method, degeneracy, alternative optimal solution, unbounded solution, infeasible solution, the dual Simplex method.	18
Unit-IV: Definition of the dual problem, the relationship between the optimal primal and dual solution, economic interpretation of duality, primal-dual computations.	18

Unit-V: Transportation, assignment and transhipment models: Definition of the transportation model, determination of a starting solution, the transportation algorithm, definition of the assignment problem, the Hungarian method.	18

References:

1. H. A. Taha: Operations Research: An introduction, 8th edition, Pearson, 2008, **(Textbook).**
2. F. Hillier and G. Liebermann: Introduction to Operations Research, 8th edition, McGraw Hill, 2005, **(Textbook).**
3. W. L. Winston: Operations Research: Applications and Algorithms, 4th edition, Cengage, 2004.
4. S. D. Sharma: Operations Research: Theory and Applications, 4th edition, Macmillan, 2010.
5. J. K. Sharma: Operations Research: Theory and Applications, 4th edition, Macmillan, 2009.

<table>
<tr><td colspan="1">Course No: 12</td><td colspan="3">Course Name: Mathematical Modeling</td><td colspan="5">Course Code: SBSMAT 03 04 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objectives of this course are to:
• Enable students understand how mathematical models are formulated, solved and interpreted.
• Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
• Equip students with the basic mathematical modelling skills</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After going through this course the students will be able to
• Enable students understand how mathematical models are formulated, solved and interpreted.
• Make students appreciate the power and limitations of mathematics in solving practical real-life problems
• Understand the concept of Empirical Modeling with Data Fitting
• Solve Mathematical models through Partial Differential equations</td></tr>
</table>

Content of Each Unit	Hours of Each Unit
Unit I Introduction to modeling, Mathematical modeling, Types of models, Characteristics of Mathematical models, Models on algebraic systems.	18
Unit-II: Modeling with Difference Equations: overview of basic concepts concerning matrices, eigenvalues and eigenvectors; fixed points, stability and iterative processes; applications to population growth.	18
Unit-III: Mathematical Models based on Ordinary differential equations, Models based on system of ordinary first order differential equations. Motion of satellites, Electrical Circuits, A curve and Persuit, Birth & Deaths model, Logistic model for growth, Models in Economics and Finance.	18

Unit-IV: Empirical Modeling with Data Fitting: error function, least squares method; fitting data with polynomials and splines. Types of Simulation, Simple Case Studies, Simulation methodology, Simulation Software, Criteria for valid and Creditable Simulation Models.	18
Unit-V: Mathematical models through Partial Differential equations: Equation of Continuity in fluid flow, Heat flow and Traffic flow. Diffusion models in air pollution, Water pollution, simple models based on heat transfer, mass transfer and wave propagation.	18

References:

1. J.N. Kapoor: Mathematical Modelling, Wiley Eastern Ltd, 1982, **(Textbook).**
2. R. Haberman: Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow, SIAM, 1998, **(Textbook)**..
3. M. Braun: Differential Equations and their Application: An Introduction to Applied Mathematics, 3rd edition, Springer, 1991.
4. A.M. Law: Simulation Modelling and Analysis, 4th edition, McGraw Hill, 2006.
5. R. M. Davies and R. M. O'Keefe: Simulation Modelling with Pascal, Prentice Hall 1989.
6. F. R. Giordano, W.P. Fox and S. B. Horton: A First Course in Mathematical Modelling, 5th edition, Cengage Learning, 2013.

11. Teaching-Learning Process

- Lectures
- Discussions
- Simulations
- Role Plays
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-enabled Learning

12. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face-to-face classroom methods with computer-based activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments face-to-face learning, giving ample freedom and flexibility to the students and teachers to access and explore wide range of open-access resources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face-to-face learning. The blended learning does not undermine the role of a teacher; rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each Program, be adopted

13. Assessment and Evaluation

- Continuous Comprehensive Evaluation at regular intervals after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the program instead of one-time assessment
- Oral Examinations to test presentation and communication skills

- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

14. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Program Outcomes
- Program Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation
- Multiple Entry
- Multiple Exit

15. References

- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website, https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf
- Guidelines for Multiple Entry and Exit in Academic Programs offered in Higher Education Institutions, https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/abc_doc.pdf
- National Education Policy-2020, https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- Quality Mandate for Higher Education in India, https://www.ugc.ac.in/e-book/Quality%20Mandate%20E-BOOK/mobile/index.html

- The draft subject specific LOCF templates available on UGC website, https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==

16. Appendix

(i) Courses of 5-year integrated BSc-MSc Mathematics having similarity more than 50% with corresponding MOOC courses have been identified, perused and discussed. These are recommended to be included for offering as equivalent courses:

List of Courses in Integrated BSc-MSc, and MSc Mathematics programs:

Sr.	CUH Program/Semester	CUH Course Title/Type(credits)	MOOC Course	Similarity
1	BSc-MSc (Integ.)/ 1ST	Calculus /Core (6)	Calculus of One Real Variable	75-80%
2	BSc-MSc (Integ.)/ 2ND	Multivariate Calculus /Core (6)	Calculus of Several Real Variables	75-80%
3	BSc-MSc (Integ.)/ 2ND	Ordinary Differential Equations/Core (6)	Differential Equations	70%
4	BSc-MSc (Integ.)/ 3RD	Group Theory /Core (6)	Introduction to Abstract Group Theory	85%
5	BSc-MSc (Integ.)/ 3RD	Probability Theory and Statistics /Core (6)	Introduction to Probability Theory and Statistics	80%
6	BSc-MSc (Integ.)/ 3RD	Real Analysis/Core (6)	Real Analysis	90%
7	BSc-MSc (Integ.)/ 4TH, 5TH	Advanced Algebra /Core (6) Linear Algebra /Core (6)	Introduction to Abstract and Linear Algebra	60% 50%
8	BSc-MSc (Integ.)/ 4TH	Partial Differential Equations and Calculus of Variation /Core (6)	Partial Differential Equations	65%
9	BSc-MSc (Integ.)/ 5TH, MSc 1ST	Linear Algebra /Core (6, 4)	Linear Algebra	75-80%
10	BSc-M.Sc (Integ.)/ 6TH	Numerical Methods /Core (6)	Numerical Methods	75-80%
11	BSc-MSc (Integ.)/ 6TH MSc/1ST	Complex Analysis/Core (6, 4)	Complex Analysis	80%
12	MSc/ 1ST, 4TH	Algebra-I /Core (4) Algebra-II /Core (4)	Rings and Modules	50% 50%
13	MSc /3 RD	Operations Research /DSEC (4)	Operations Research	90%
14	MSc /4TH	Measure Theory and Integration /DSEC (4)	Measure Theory	90%

MOOC courses (SWAYAM) having similarity more than 75% with the core courses may be offered to the students. For SEC/GEC/AECC/DCEC/DSEC courses, the students may opt from the MOOC courses provided these courses are not in the list of core courses and student have not studied similar courses earlier. Since, the list of MOOC courses (SWAYAM) keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

(ii) Structure of Question Papers and Marks Distribution

		Distribution of Marks
		(Max. Marks=100)
Continuous Assessment		**Max. Marks=30**
	Sessional-I	10
	Sessional-II	10
	Quiz/Assignment	5
	Attendance	5
End Term Examination **(3 Hours)**		**Max. Marks=70**
		(i) Question 1 has seven sub-parts (short answer-type) at least one from each unit and students need to answer any five. Each sub-part carries 2 Marks. (5x2=10) (ii) Question 2 to 6 (one from each unit) have three sub-parts each, and students need to answer any two. Each sub-part carries 6 marks. (2x6x5=60 marks).

Annexure-IV

Minutes of Board of Studies (BoS) Meeting held on 11.05.2022 at 11:00 AM

4 messages

Geography Department <hodgeography@cuh.ac.in> Thu, May 12, 2022 at 5:12 PM
To: kahlon_s@pu.ac.in, subhash anand <sanandpv@yahoo.co.in>, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>
Bcc: "Dr. Jitendra Kumar" <jitendra@cuh.ac.in>

Respected Madam/Sir

Minutes of Board of Studies (BoS) Department of Geography 11.05.2022

A meeting of the Board of Studies (BoS) of the Department of Geography was held on 11.05.2022 at 11:00 AM (Through online mode; Link: https://meet.google.com/rwe-wodb-iba) and the following members were present during the meeting:

1. Dr. Jitendra Kumar, Head, Department of Geography, School of Basic Sciences, Central University of Haryana, Mahendergarh (Chairperson).
2. Prof. Simrit Kahlon, Department of Geography, Panjab University, Chandigarh. (External Member).
3. Prof. Subhash Anand, Department of Geography, University of Delhi, Delhi (External Member).
4. Dr. Manish Kumar, Department of Geography, School of Basic Sciences, Central University of Haryana, Mahendergarh. (Internal Member)

The following agenda were taken up and discussed in the meeting for consideration and approval of the Board of Studies (BoS) of the Department of Geography, Central University of Haryana:

Agenda 1

To consider and approve the Minutes of the Departmental Research Committee (DRC) of the Department of Geography held on 20.04.2022 **(Enclosure-I).**

Resolution: The Board of Studies (BoS) considered and approved the Minutes of the Departmental Research Committee (DRC) of the Department of Geography held on 20.04.2022.

Agenda 2

To consider and approve the list of panels of examiners (external and internal) for M.Sc. Geography and Ph.D. Course Work for Odd and Even Semesters for Term End Examination, 2022 **(Enclosure-II).**

Resolution: The Board of Studies (BoS) considered and approved the list of panels of examiners (external and internal) for M.Sc. Geography and Ph.D. Course Work for Odd and Even Semesters for Term End Examination, 2022.

Agenda 3

Any other item(s) with the permission of the Chair.

Resolution: None

You are kindly requested to consider and approve items 1 & 2 of the agenda mentioned in the minutes of the Board of Studies (BoS) meeting held on 11.05.2022 at 11:00 AM (Through online mode).

--
Regards
Dr. Jitendra Kumar
Head of the Department
Associate Professor
Department of Geography
School of Basic Sciences

Central University of Haryana
Jant-Pali, Mahendergarh
Haryana – 123031, INDIA
Alternate E-mail: jitendra@cuh.ac.in
Mobile/WhatsApp: +91-9812492229

---

2 attachments

Annexure-I_DRC Minutes_20-04-2022.pdf
2000K

Annexure_II_Panel of Examiner_2022.xlsx
27K

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kahlon_s <kahlon_s@pu.ac.in> Thu, May 12, 2022 at 5:45 PM
To: Geography Department <hodgeography@cuh.ac.in>

The minutes of the Board of Studies of Department of Geography held on May 11, 2022 are hereby approved

Simrit Kahlon

Professor

Department of Geography

Panjab University

Chandigarh

[Quoted text hidden]

Dr. Manish Kumar <manish.ks@cuh.ac.in> Fri, May 13, 2022 at 1:32 AM
To: Geography Department <hodgeography@cuh.ac.in>
Cc: kahlon_s@pu.ac.in, subhash anand <sanandpv@yahoo.co.in>

Approved Agenda 1 and 2

[Quoted text hidden]

---

subhash anand <sanandpv@yahoo.co.in> Fri, May 13, 2022 at 8:46 AM
Reply-To: subhash anand <sanandpv@yahoo.co.in>
To: "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>
Cc: kahlon_s@pu.ac.in

Dear Dr Jitendra

I approved the minutes of all agenda

Thank you very much

Sent from Yahoo Mail on Android
[Quoted text hidden]

DEPARTMENT OF GEOGRAPHY
CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh (Haryana)-123031

Minutes of DRC meeting held on 20.04.2022

A meeting of Departmental Research Committee (DRC) was held on 20.04.2022 at 1.30 P.M. in the office of the Head, Department of Geography, Room No. 310, Academic Block-4.

Following members were present in the meeting:

1. Dr. Jitendra Kumar, Associate Professor & Head, Department of Geography, Central University of Haryana, Mahendergarh (Chairman)
2. Prof. S.P. Kaushik Department of Geography, Kurukshetra University, Kurukshetra (External Expert)
3. Dr. Manish Kumar, Assistant Professor, Department of Geography, Central University of Haryana, Mahendergarh (Member)
4. Dr. Kheraj, Assistant Professor, Department of Geography, Central University of Haryana, Mahendergarh (Member)

The following agenda were taken up and discussed in the meeting for consideration and approval of the Departmental Research Committee (DRC) of the Department of Geography, Central University of Haryana.

Agenda 1
To consider the request for allocation of a research supervisor to Mr. Kousik Das Malakar (Roll No. 200781). **(Annexure I).**

Agenda 2
To consider the request for allocation of a research supervisor to Mr. Mahendra Yadav (Roll No. 200782). **(Annexure-II).**

Resolution:
In reference to agenda 1&2: Owing to the resignation of Dr. Gloria Kuzur from CUH and shifting to IGNOU, New Delhi and while redistributing/reallocating the Supervisors to the already registered candidates (02 PhD students) earlier under her supervision, the allotment of Research Supervisor was finalized by DRC after going through the various options given by research scholars and subsequent deliberations, as given below-

Roll No	Registration No.	Name of the Research Scholar	Name of the allotted Supervisor
200781	CUH20067200781	Kousik Das Malakar	Dr. Manish Kumar
200782	CUH20067200782	Mahendra Yadav	Dr. Jitendra Kumar

Jitendra 20-04-2022   20.4.2022   Manish 20/04/2022   Kheraj 20/04/2022

The research scholars may modify their title in consultation with research supervisor and vice-versa.

Agenda 3
To consider the request of Dr. Gloria Kuzur as Co-supervisor. **(Annexure-III)**

Resolution
The DRC considered and approved Dr. Gloria Kuzur (Assistant Professor (Distance Education), Staff Training and Research Institute of Distance Education (STRIDE), IGNOU, New Delhi to act as Co-supervisor for Kousik Das Malakar (Roll No. 200781) and Mahendra Yadav (Roll No. 200782).

Agenda 4
To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job. **(Annexure-IV)**

Resolution

Mr. Sourabh Yadav (Roll No. 200785) Registration No. (CUH20067200785) has joined the PhD program on 29-11-2020 and resigned his fellowship on 01-12-2021 and joined the regular job on 01-12-2021 as a Lecturer Inter College, Jasrana, Firozabad (Uttar Pradesh Secondary Education Service Selection Board). DRC considered the case of Mr. Sourabh Yadav. It was recommended that candidate may be allowed to continue his PhD program subject to the condition to complete a residential period of two years (under Clause 9 (e). of PhD ordinance-II (A) of Central University of Haryana amended vide Resolution No-3(A) of the 45th meeting of the Executive Council dated 27.01.2020) by taking leave from his employer. However, candidate has submitted NOC, where it has been mentioned that no separate leave will be given to Saurav Yadav. The case may be submitted for consideration and approval to the competent authority.

Agenda 5
Any other item(s) with the permission of the Chair.

Resolution
None

The meeting ended with a vote of thanks.

Dr. Jitendra Kumar	Prof. S.P. Kaushik	Dr. Manish Kumar	Dr. Kheraj

Dean School Of Basic Sciences <deansobs@cuh.ac.in>

School Board Meeting on 12-09-2022 at 10:30 A.M. onwards

Dean School Of Basic Sciences <deansobs@cuh.ac.in> Wed, Sep 14, 2022 at 12:34 PM
To: "आचार्य पवन कुमार शर्मा Prof. Pawan K. Sharma" <talk2pawan@gmail.com>
Cc: bonnie_kahlon@yahoo.com, ckjaggi@gmail.com, sukhdeepsingh.cse@dcrustm.org, amitach1@yahoo.com, Amita Chandra <achandra@physics.du.ac.in>, HoD Maths <hodmaths@cuh.ac.in>, HOD Physics <hodphysics@cuh.ac.in>, HOD Statistics <hodstatistics@cuh.ac.in>, CS and IT <hodcomputerscience@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>, "HoD, Chemistry" <hodchemistry@cuh.ac.in>, ssunita@cuh.ac.in, "Dr. Suneel Kumar" <suneelkumar@cuh.ac.in>, "Dr. Harish Kumar" <harishkumar@cuh.ac.in>, Rajeshgupta@cuh.ac.in, "Dr. Manoj Gupta" <mkgupta@cuh.ac.in>, keshav@cuh.ac.in, Suraj Arya <surajarya@cuh.ac.in>, jitendra@cuh.ac.in, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, arunkajla@cuh.ac.in, "Dr. Rakesh Kumar" <rks@cuh.ac.in>, "Dr. Kapil Kumar" <kapilstats@cuh.ac.in>, kahlon_s@pu.ac.in, "Dr. Vinod Kumar" <vinodkumar@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Devendra Kumar" <devendrastats@cuh.ac.in>, drjitendra@cuh.ac.in

Respected Madam/Sir,
Please find herewith the revised minutes (with minor modification in resolution for agenda no 3a and 3b) of the meeting of the School Board held on 12-09-2022 for your kind consideration and approval.
With Warm Regards

(Revised) Minutes of Meeting of the School Board of School of Basic Sciences held on 12.09.2022

A meeting of the **School Board of School of Basic Sciences**, Central University of Haryana, Mahendergarh was held on **12.09.2022** at **10:30 A.M.** onwards via offline and online (https://meet.google.com/rvh-ukja-fwm) mode in the office of the Dean, School of Basic Sciences, Central University of Haryana.

The following members were present in the meeting:

1. **Dr. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Dr. Keshav Singh Rawat** (Member)
   Head, Department of Computer Science and IT
   Central University of Haryana, Mahendergarh
3. **Dr. Jitendra Kumar** (Member)
   Head, Department of Geography
   Central University of Haryana, Mahendergarh
4. **Dr. Rajesh Kumar Gupta** (Member)
   Head, Department of Mathematics
   Central University of Haryana, Mahendergarh
5. **Dr. Suneel Kumar** (Member)
   Head, Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
6. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
7. **Prof. Sunita Shrivastava** (Member)
   Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
8. **Dr. Manoj Kumar Gupta** (Member)

Department of Chemistry
Central University of Haryana, Mahendergarh

9. **Dr. Suraj Arya** (Member)
Department of CS & IT
Central University of Haryana, Mahendergarh

10. **Dr. Manish Kumar** (Member)
Department of Geography
Central University of Haryana, Mahendergarh

11. **Dr. Arun Kajla** (Member)
Department of Mathematics
Central University of Haryana, Mahendergarh

12. **Prof. Pawan Kumar Sharma** (External Subject Expert)
Professor, Department of Chemistry
Kurukshetra University, Kurukshetra, Haryana

13. **Prof. Chandra K. Jaggi** (External Subject Expert)
Professor, Department of Operational Research
Faculty of Mathematical Sciences, DU, Delhi

14. **Prof. Sukhdeep Singh** (External Subject Expert)
Professor, Department of Computer Science & Engg.
DCRUST, Murthal, Sonipat

15. **Prof. Amita Chandra** (External Subject Expert)
Professor, Department of Physics & Astrophysics Joined online
North Campus, DU, Delhi

16. **Prof. Simrit Kahlon** (External Subject Expert)
Professor, Department of Geography
Panjab University, Chandigarh

17. **Prof. Anil Kumar Yadav** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

18. **Dr. Jitendra Kumar** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

19. **Dr. Devendra Kumar** (Special Invitee)
TIC, Department of Statistics
Central University of Haryana, Mahendergarh

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

Item No	**Description and Recommendation**	**Annexure**
1	Confirmation of the minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022.	
	The minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022 were confirmed.	**Annexure-1-SOBS**
2	To consider and approve the minutes of the meeting of the Board of	

	Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022, be approved.	**Annexure-A**
2a	To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-CH**
2b	To consider and approve the Scheme for first three years and Syllabi for second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in the BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc. programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020. **It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.** **Resolved that the Scheme for first three years (with minor modifications in first and second year) and Syllabi for the second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-II-CH**
2c	To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of	

	Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme and syllabi of the Integrated B.Sc.-M.Sc. programme have been designed. **Resolved that the Scheme and Syllabi for the first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-III-CH**
3.	To consider and approve the minutes of the meetings of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022, be approved.	**Annexure-B**
3a	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and suggested the improvement in the course title of Programming for Data Science as "Programming for Data Science using python" in the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023). **Further, the board suggested that the Department of Computer Science and Department of Statistics should sit together and should try to come up with a Collaborative model for the M.Sc. Data Science programme. In view of that the board resolved that the first semester Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, with minor changes as mentioned above be approved and recommended the same to the Academic Council for consideration and approval.**	**Annexure-I-CS**
3b	To consider and approve the Scheme and Syllabi of the Diploma in	

	Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and the board noted that the proposed one year Diploma Programme is of UG level and of 40 credits. However, the existing CUH ordinance allows the Diploma at PG level only with 52 credits(+-4). In view of that the board suggested that the Diploma in Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022, may be offered after the amendments in the university ordinance regarding guidelines of credits for the UG degree level diploma with updated syllabi.	**Annexure-II-CS**
4.	To consider and approve the minutes of the meeting of the Board of Studies of the Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022.	
	Resolved that the minutes of the meeting of Board of Studies of Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022, be approved	**Annexure-C**
4a	To consider and approve the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval after the incorporation of suggested corrections given below: **i) The name of the course "Solar Energy and Physics of Voltaic" is to be changed as "Fundamentals of Solar Energy".** **ii) In case of "Dissertation" offered to students in Semester IV, it should be explicitly mentioned that a continuous monitoring is required to be done. For that purpose, a minimum of two presentations are to be presented by students during the semester.** **iii) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of M.Sc. (Physics) 2021-23 batch.**	**Annexure-I-PH**
4b	To consider and approve the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session	

	2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Discussed in detail the Schemes and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme w.e.f. Academic Session 2022-2023 (Annexure-IIB-PH)and for 2021-26 batch (Annexure-IIA-PH). **Resolved that the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session 2022-2023) and for 2021-26 batch as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to implementation of below-mentioned changes:** **i) The number of practical lectures for DSE, mentioned in the schemes of Semester V and Semester VI should be four instead of two.** **ii) In case of "Dissertation" offered to students in Semester X, it should be explicitly mentioned that a continuous monitoring is required. For that purpose, a minimum of two presentations by each student are required during the semester.** **iii) A course related to "Soft Skills" may be added in the list of Ability Enhancement courses that can be offered by Department of Psychology, or Department of Education or Department of English Studies** **iv) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of Integrated B.Sc. M.Sc (Physics) for 2021-26 batch.**	**Annexure-IIA-PH** **Annexure-IIB-PH**
4c	To consider and approve the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to incorporation of below-mentioned changes: **i) The number of DCEC courses for the PhD (Physics) course work should be three. Therefore, it was decided unanimously to remove the course of "Nanotechnology and Ion Beam".**	**Annexure-III-PH**

5.	To consider and approve the minutes of the meeting of Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022	**Annexure-D1, D2, D3**
	Resolved that the minutes of the meeting of the Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022 be approved.	
5a	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-MT**
5b	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2022-27 (1-6 Semesters) as approved in BOS meeting of Department of Mathematics held 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	**Annexure-II-MT**
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics w.e.f Academic Session 2022-23, as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved, and recommended the same to Academic Council for consideration and approval.	
5c	Recommendation on the application dated 07-01-2022 received from Mr. Manish Kumar (Roll no. 191217), Research Scholar, on the recommendation of DRC (**Annexure–III-MT**), Department of Mathematics dated 13-01-2022 and BoS (16-03-2022, **Annexure-D1**).	**Annexure-III-MT**
	The case of Mr. Manish Kumar (Roll no. 191217), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 09-08-2019 and the topic of his research was approved on 19-11-2020 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Manish Kumar (Roll no. 191217), Research Scholar is required to complete a minimum residency period of two years after his topic approval date as per clause no 7.10 and 9f of Ordinance-II(A) 2019 for Ph.D. It is further resolved that the remaining**	

	residency period of 10 months 13 days should be completed in one go by Mr. Manish Kumar as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.	
6.	To consider and approve the minutes of the meeting of the Board of Studies (BOS) of the Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of Department of Statistics, School of Basic Sciences held on 10-05-2022 be approved.	**Annexure-E**
6a	To get approval for changing the instructions/notes in the course for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that changing the instructions/notes in the courses for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022, be approved and recommended the same to the Academic Council for consideration and approval.	**Annexure-E**
6b	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics, held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	<u>The agenda item 6b is withdrawn</u> as the similar programme i.e. M.Sc. Data Science has been offered by the Department of Computer Science & Information Technology under the same School. **After detailed discussion, the board suggested that the Department of Statistics and Department of Computer Science & Information Technology may start some collaborative and common programmes in near future as per the availability of the faculty members and resources.**	**Annexure-I-ST**
6c	To consider and approve the Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the revised and updated Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics	**Annexure-II-ST**

	held on 10-05-2022, be approved and recommended the same to Academic Council for consideration and approval.	
7.	To consider and approve the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3).	
	Resolved that the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3) be approved.	**Annexure-F1, F2, F3**
7a	To consider and approve the syllabus of M.Sc. Geoinformatics programme in the Department of Geography.	
	Resolved that Scheme and Syllabi of M.Sc. Geoinformatics, two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Geography held on 24-08-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-Geog**
7b	To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job as recommended by Departmental Research Committee (DRC) held on 20-04-2022 and Board of Studies (BoS) meeting held on 11-05-2022 and to recommend the case for Academic Council.	
	The case of Mr. Sourabh Yadav (Roll no. 200785), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 29-11-2020 and the topic of his research was approved on 26-10-2021 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Sourabh Yadav (Roll no. 200785), Research Scholar is required to complete a minimum period of two years after his topic approval date as per clause no 9e and 9f of Ordinance-II(A) for Ph.D 2020. It is further resolved that the remaining period of 1 year 10 months 27 days should be completed in one go by Mr. Sourabh Yadav as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.**	**Annexure-II-Geog**
8.	Any other item(s) with the permission of the Chair.	
	No item was discussed	

The meeting ended with thanks to the Chair.

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

CBCS, LOCF AND NEP-2020 BASED

Curriculum and Syllabi of M.Sc. Geoinformatics

(*w.e.f.* 2022-23)

DEPARTMENT OF GEOGRAPHY
SCHOOL OF BASIC SCIENCES

Approved by:	**BOS**	**School Board**	**Academic Council**
Approval Status:	√	√	
Approval Date:	24.08.2022	12.09.2022	

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VISION AND MISSION

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavors, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

1. BACKGROUND

1.1. NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Road map identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the policy, enabling them to revise the curriculum in sync with the policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasizing upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; alignment of vocational courses with the International Standard Classification of Occupations maintained by the International Labor Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted a series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

1.2. ABOUT THE SUBJECT

Geoinformatics is the art, science and technology of acquisition, storage, processing, production, visualization, and dissemination of geospatial features/phenomena by means of computerized/digital systems. It generates geoinformation and uses that to deal with problems in geography, cartography, geosciences, and related engineering disciplines. Geoinformatics is underpinned by technologies including remote sensing, geographic information systems (GIS), global navigation satellite system (GNSS) and surveying and mapping, which facilitate the capture, analysis, and visualisation of spatial data.

Geoinformatics seeks to accomplish three fundamental tasks: (1) data collection or generation, (2) data storage and dissemination, and (3) geographical data analysis, modelling, and interpretation. These operations are carried out by the geoinformatics domains. Remote sensing is the art and science of acquiring information about an object or feature without coming into direct contact with it. It enables the inference of surface parameters and the investigation of spatial dynamics in inaccessible locations using measurements of electromagnetic radiation (EMR) reflected or emitted by the earth's surface. As a result, the coverage of space-based remote sensing systems is synoptic, allowing for the investigation of phenomena on macroscales. All forms of data are created, stored, managed, analysed, mapped, and modelled using a geographic information system. It integrates location data with all forms of descriptive information by connecting data to a map. This sets the stage for mapping, modeling, and analysis, which are all used in science and almost every other field. GIS enables users to comprehend patterns, relationships, and spatial context. Among the benefits are enhanced communication and efficiency, as well as improved management and decision-making. Global navigation satellite system provides for an autonomous system of precise geospatial placement over the surface of the globe. The satellite system precisely covers the entire globe and generates main positioning data in the form of coordinates for each and every geographical point. While these three disciplines constitute the foundation of geoinformatics, the subject as a whole is not restricted to them. Data sourcing (both spatial and non-spatial) is pervasive. Geoinformatics encompasses a broad range of challenges and is constantly increasing, to the point where the discipline has become global and transdisciplinary. Since then, it has grown to include planning, architecture, modelling and simulation, hazard management, and studies of biogeographical evolution in addition to resource management.

Geoinformatics has aided the transformation of fundamental knowledge disciplines into more applied, resolution-oriented fields of analysis. As a result, researchers have evolved into problem-solvers that effectively and efficiently deal with geo-environmental issues across local, regional and global scales.

1.3. About the Programme

1.3.1. Nature and extent of the Programme

Geoinformatics is a growing and dynamic field in the current world, and its domains, particularly GIS and remote sensing, are rapidly becoming standard tools, influencing practical decision-making, particularly among professionals and planners.

The post-graduate Geoinformatics course, devised in accordance with the learning outcome-based curriculum system (LOCF), incorporates both foundational and practical issues. This M.Sc. Geoinformatics programme is designed to provide students with both theoretical and practical knowledge of geospatial science and technology, enabling them to gain comprehensive and unique perspectives on real-world spatial problems, develop new advanced tools/methods for the acquisition, transformation, processing and analysis, storage and interpretation of spatial information, and conduct high-quality interdisciplinary research studies. The course incorporates applications from a variety of disciplines, including Earth Sciences, Disaster Management, Natural Resource Management, Land Use Planning, Agriculture, Forestry, Wildlife Habitat Management, and Urban Transportation and Supply Network Management. The course is designed to require students to use computers throughout the duration of the programme, allowing them to work with the most current versions of software available in the fields of GIS and Remote Sensing.

Rather than continuing the previous curriculum, LOCF proposes an alternative strategy for improving the quality of higher education by defining milestones in terms of outcomes (knowledge, comprehension, skills, attitudes, and values) and academic standards expected of students upon degree completion. The first two semesters of the programme are devoted to theoretical and hands-on laboratory training of core courses. The latter are associated with advanced geospatial science and technology. Additionally, LOCF strives to materialize global rivalry and strengthen the disciplines' applied aspects. Accordingly, the last semester is for a major skill enhancement course (dissertation) where students will be working on real-life projects, as per their interest and produce a dissertation-style research report leading to the completion of the programme. The Department will also assist students in identifying appropriate institutions for conducting their research. Students will have the opportunity to meet with specialists from famous institutions across India in this context.

1.3.2. Aims of the Programme

On completion of their Master's Degree Programme, students of geoinformatics will:

- Possess an in-depth knowledge of the concepts, methods, and subject matter of geoinformatics and its sub-domains.
- Possess a thorough knowledge of the concepts and technical elements of GIS, remote sensing, and GNSS.
- Develop a deep understanding of geographic phenomena, fields, processes, and objects, as well as the skills to collect and analyse geographic data in a way that helps you understand spatial phenomena and use the results for analysis.
- Be familiar with innovations in geoinformatics, and its integrations such as those with cloud computing, artificial intelligence-based spatial modelling (machine learning and deep learning) etc.
- Concentrate on geoinformatics applications such as natural resource management, disaster management, urban planning, utility management, smart city development, environmental management, water resource management, and forestry.
- Learn about geoinformatics and find new ways to use it in geographic, environmental, cartographic, and statistical analysis.
- Develop highly skilled personnel to ensure that the vision of digital India is realised.
- Have a good understanding of the laws, rules, and morals that govern how maps and remote sensing data can be used.

1.3.3. Qualification/Eligibility/Intake Capacity

Duration:

M.Sc. Geoinformatics is a full-time postgraduate level programme offered by the Department of Geography. This is a 2-years program, consisting of four semesters with two semesters per year.

Eligibility Criteria

The eligibility criteria of M.Sc. Geoinformatics have been given below:

The student must have completed their Bachelor's (Hons/Major) degree from any Indian or foreign university recognized by UGC either in the fields of Geography / Environmental Science / Forestry / Chemistry / Physics / Geology / Geophysics / Mathematics / Oceanography/ Agriculture/ Atmospheric Sciences/ Climatology/ Information Science/ Computer Science/ Disaster Management/ Engineering / Town Planning / Architecture /

Botany/ Zoology/ allied disciplines with at least 50% marks or equivalent grade in aggregate and relaxation of 5% to the SC/ST/PWD/OBC (Non-Creamy Layer) candidates).

OR

B.A./B.Sc. with Geography with at least 50% marks or equivalent grade in aggregate and relaxation of 5% to the SC/ST/PWD/OBC (Non-Creamy Layer) candidates).

OR

Masters in Geography with at least 50% marks or equivalent grade in aggregate and relaxation of 5% to the SC/ST/PWD/OBC (Non-Creamy Layer) candidates).

Intake capacity

- The department offers 20 seats for admission under the programme of M.Sc. Geoinformatics.

Mode of M.Sc. Geoinformatics Programme

- Regular

Medium of Instruction

- Should be English only

1.4 Qualification Descriptors (Possible Career Pathways)

The qualification descriptors for the programme in geoinformatics will enable students to improve their learning attributes such as understanding, communication, subject knowledge expansion, and application with a clear understanding of one's location, and to join the workforce in the field of geography and geoinformatics. Geoinformatics is a scientific and technological course that uses and develops information science to address challenges in geography, geo-sciences, and cartography, and branches related to science and engineering.

The geoinformatics course contains advanced lessons in space technologies, geographical models, analysis networks, and so on. It will provide students with a thorough understanding of how geoinformatics is assisting in the learning of new things in society.

The course may be followed as a postgraduate degree in geoinformatics, and students are expected to meet professional standards, find a good balance between work and life, and live productive, meaningful lives. They should also be able to understand and explain things clearly and think critically. Each student in geoinformatics programme should be able to:

(a) ***Demonstrate*** a coherent and systematic knowledge and understanding of the field of GIS and its theoretical developments, along with its practical implementations.

(b) ***Demonstrate*** the ability to understand the conceptual framework of remote sensing and aerial photogrammetry and its associating factors in a changing world in different dimensions.

(c) ***Demonstrate*** the ability to think and relate different processes that occur on earth's surface.

(d) ***Reflecting*** and ***Communicating*** ideas and opinions through different research and development in the form of essays, dissertations, reports, findings etc., in shaping the society and communicating through different platforms such as the classroom, conferences, seminars, workshops, the media and the internet.

(e) ***Recognize*** the scope of geospatial techniques and values in terms of career opportunities, employment and lifelong engagement in teaching, publishing, translation, communication, media, soft skills and other allied fields.

(f) ***Apply*** one's problem-solving knowledge and transferable skills to new or unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.

(g) ***Use*** knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study and accomplishing an analytical approach.

(h) ***Demonstrate*** skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject(s) for formulating evidence- based solutions and arguments.

There are many organisations where a geo-informatics student can establish his/her career. As a Teacher (College & University), Indian Space Research Organization Centres (ISRO, Govt. of India), Defense Research & Development Organization (DRDO, Ministry of Defense), State Remote Sensing Centres, Department of Science & Technology, National Thematic Mapping Organization (NATMO), National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), and other Government of India departments. Those who gain technical expertise in areas such as Geographic Information Systems (GIS) and remote sensing can be in high demand from both the public and private sectors.

Those who gain technical expertise in areas such as Geographic Information Systems (GIS) and remote sensing can be in heavy demand from both the public and private sectors. Other options include:

- GIS Technician

- GIS Analyst
- Web Mapping and Web GIS
- GIS Developer
- GIS Officer
- Cartographers
- Environmental Planning and Management
- Geo-Scientist
- Geological Assistant
- Weather Analyst
- Landscape Architect & Manager
- Teaching, Research & Development

2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attaining important essential skills and abilities:

PO-NO.	COMPONENT	OUTCOMES
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.

PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a group and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	Lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post-graduate students shall be able to realise the following specific outcomes by the end of programme:

NUMBER	PROGRAMME SPECIFIC OUTCOMES
PSO-1	Developing a broad conceptual understanding along with practical exploration of the concept of detecting and monitoring the physical characteristics of an area through Remote Sensing, GIS, Cartography and GNSS in geospatial studies.
PSO-2	A deep knowledge of aerial photographs, satellite images, and digital image interpretation has been found as an indispensable tool in topographical mapping and enables students to extract all necessary interpretations from the images.
PSO-3	For exploring the concept and application of geospatial data, Web-GIS and the role of geoinformatics in disaster and natural resource management, which will be useful for planning purposes.
PSO-4	Developing the concept of law and policy about map making and utilisation of geospatial data will make students aware of constraints in the field of geospatial analysis.
PSO-5	Students will be able to understand the current trends in the fields of GIS and remote sensing. As remote sensing gets better, students will learn about thermal, hyperspectral, microwave, LIDAR, and UAV technologies.

PSO-6	Geoinformatics is now being used in the fields of master planning, smart city development, water resources, the environment, and forest management.

4. POSTGRADUATE ATTRIBUTES

On completion of the Post Graduate Programme in Geo-informatics, students are expected to be equipped with the skills of creative, critical and rational thinking associated with GIS and its use for human society. The following attributes are expected from the students:

No.	P.G. ATTRIBUTES
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills, Life Skill
PGA-8	Global Competency

5. STRUCTURE OF MASTER'S COURSE

Types of Courses	Nature	Total Credits	%
Core Courses (CC)	Compulsory	76	79.16
Elective Courses (EC)	Discipline Centric Elective Courses	12	12.5
	Generic Elective Courses	08	8.33

Course Type Core Courses (CC)
Generic Elective Courses (GEC)
Discipline Centric Elective Courses (DCEC)

Total Credit: 96, Semester-wise distribution of credits: 24+ 24 + 24 + 24

LIST OF COURSES

Sr. No .	Course No	Course Code	Course Title	Course Type	Credit	Semester
CORE COURSES (CC)						
1	CC 1	SBS GEO 3 1 0 1 C 3 1 0 4	Principles of Remote Sensing	CC	4	I
2	CC 2	SBS GEO 3 1 0 2 C 3 1 0 4	Principles of GIS, Cartography and GNSS	CC	4	I
3	CC 3	SBS GEO 3 1 0 3 C 3 1 0 4	Introduction of Aerial Photograph & Photogrammetry	CC	4	I
4	CC 4	SBS GEO 3 1 0 4 C 2 0 2 4	Practical 1: GIS	CC	4	I
5	CC 5	SBS GEO 3 1 0 5 C 2 0 2 4	Practical 2: Cartography and GNSS	CC	4	I
6	CC 6	SBS GEO 3 2 0 6 C 3 1 0 4	Spatial data Modeling and its Applications	CC	4	II
7	CC 7	SBS GEO 3 2 0 7 C 3 1 0 4	Fundamentals of Digital Image Processing	CC	4	II
8	CC 8	SBS GEO 3 2 0 8 C 3 1 0 4	Research Methodology and Report Writing	CC	4	II
9	CC 9	SBS GEO 3 2 0 9 C 2 0 2 4	Practical 3: Digital Image Processing and Information Extraction	CC	4	II
10	CC 10	SBS GEO 3 3 1 0 C 3 1 0 4	Advances in GIS and Future Trends	CC	4	III
11	CC 11	SBS GEO 3 3 1 1 C 3 1 0 4	Advances in Remote Sensing	CC	4	III
12	CC 12	SBS GEO 3 3 1 2 C 2 0 2 4	Practical 4: Geo-Statistics & Statistical Applications in GIS	CC	4	III
13	CC 13	SBS GEO 3 3 1 3 C 3 1 0 4	Application of Geoinformatics in Urban Studies	CC	4	III
14	CC 14	SBS GEO 3 4 1 4 C 00024	Dissertation	CC	24	IV

DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC) **(Offered to the students of M.Sc. Geoinformatics by the Department)**						
1	DCEC 1	SBS GEO 3 2 0 1 DCEC 3 1 0 4	Law and Policy for Maps and Remote Sensing Data	DCEC	4	II

2	DCEC 2	SBS GEO 3 2 0 2 DCEC 3 1 0 4	Web-GIS	DCEC	4	II
3			MOOC 1	DCEC	4	II
4	DCEC 3	SBS GEO 3 3 0 3 DCEC 3 1 0 4	Application of Geoinformatics for Water Resource Management	DCEC	4	III
5	DCEC 4	SBS GEO 3 3 0 4 DCEC 3 1 0 4	Application of Geoinformatics in Environmental Management	DCEC	4	III
6	DCEC 5	SBS GEO 3 3 0 5 DCEC 3 1 0 4	Application of Geoinformatics in Disaster Management	DCEC	4	III
7	DCEC 6	SBS GEO 3 3 0 6 DCEC 0 4 0 4	Seminar	DCEC	4	III
8			MOOC 2	DCEC	4	IV

GENERIC ELECTIVE COURSES (GEC) **(Offered to PG students of other departments only)**						
1	GE 1	SBS GEO 3 1 0 1 GE 3 1 0 4	Fundamentals of Geographic Information System	GEC	4	I
2	GE 2	SBS GEO 3 1 0 2 GE 3 1 0 4	Fundamentals of Remote Sensing & Aerial Photograph	GEC	4	I
3	GE 3	SBS GEO 3 2 0 3 GE 3 1 0 4	Application of Geoinformatics in Disaster Management	GEC	4	II
4	GE 4	SBS GEO 3 2 0 4 GE 3 1 0 4	Application of Geoinformatics in Natural Resource Management	GEC	4	II

6. LEARNING OUTCOME INDEX

6.1 Core Courses (CC):

‘PSOs **Course No.**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**
CC 1	√	√	√	√	√	

CC 2	√	√	√	√	√	√
CC 3	√	√			√	√
CC 4		√		√	√	√
CC 5	√		√	√	√	
CC 6		√		√	√	√
CC 7	√	√		√	√	√
CC 8		√	√	√		
CC 9	√	√	√	√	√	√
CC 10	√	√	√	√	√	√
CC 11	√	√	√	√	√	√
CC 12	√	√	√		√	
CC 13	√	√	√	√	√	
CC 14	√	√	√	√	√	√

6.2 Discipline Centric Elective Courses (DCEC):

PSOs / **Course No.**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**
DCEC 1	√		√	√	√	
DCEC 2	√	√	√	√		√
DCEC 3		√	√		√	
DCEC 4	√	√		√	√	√
DCEC 5	√	√	√	√	√	√
DCEC 6	√	√	√		√	√

6.3 Generic Elective Course (GEC):

PSOs / **Course No.**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**
GEC 1	√	√	√	√		√
GEC 2		√	√	√	√	√

GEC 3	√			√	√	
GEC 4	√	√	√	√	√	√

7. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

SEMESTER-I (Total Credits = 24)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credit
Core Courses								
1	CC 1	SBS GEO 3 1 0 1 C 3 1 0 4	Principles of Remote Sensing	3	1	0	4	4
2	CC 2	SBS GEO 3 1 0 2 C 3 1 0 4	Principles of GIS, Cartography and GNSS	3	1	0	4	4
3	CC 3	SBS GEO 3 1 0 3 C 3 1 0 4	Introduction of Aerial Photograph & Photogrammetry	3	1	0	4	4
4	CC 4	SBS GEO 3 1 0 4 C 2 0 2 4	Practical 1: GIS	2	0	4	6	4
5	CC 5	SBS GEO 3 1 0 5 C 2 0 2 4	Practical 2: Cartography and GNSS	2	0	4	6	4
6	**GEC (to be taken from other departments) / MOOC**							4
Generic Elective Courses (for students of other Departments)								
7	GE 1	SBS GEO 3 1 0 1 GE 3 1 0 4	Fundamentals of Geographic Information Systems	3	1	0	4	4
8	GE 2	SBS GEO 3 1 0 2 GE 3 1 0 4	Fundamentals of Remote Sensing & Aerial Photograph	3	1	0	4	4
Total Credit Semester I							**24**	

SEMESTER-II (Total Credits =24)

Sr. No.	Course No	Course Code	Course Title	L	T		P	Hrs/Week	Total Credit
	Core Courses								
1	CC 6	SBS GEO 3 2 0 6 C 3 1 0 4	Spatial data Modeling and its Applications	3	1		0	4	4
2	CC 7	SBS GEO 3 2 0 7 C 3 1 0 4	Fundamentals of Digital Image Processing	3	1		0	4	4
3	CC 8	SBS GEO 3 2 0 8 C 3 1 0 4	Research Methodology and Report Writing	3	1		0	4	4

4	CC 9	SBS GEO 3 2 0 9 C 2 0 2 4	Practical 3: Digital Image Processing and Information Extraction	2	0		4	6	4
5	**GEC (to be taken from other departments)/ MOOC**								**4**
Discipline Centric Elective Courses (any one from the list)									
6	DCEC 1	SBS GEO 3 2 0 1 DCEC 3 1 0 4	Law and Policy for Maps and Remote Sensing Data	3	1		0	4	4
7	DCEC 2	SBS GEO 3 2 0 2 DCEC 3 1 0 4	Web-GIS	3	1		0	4	4
8			MOOC 1*	-	-		-	-	4
	Generic Elective Courses (for students of other Departments)								
9	GE 3	SBS GEO 3 2 0 3 GE 3 1 0 4	Application of Geoinformatics in Disaster Management	3		1	0	4	4
10	GE 4	SBS GEO 3 2 0 4 GE 3 1 0 4	Application of Geoinformatics in Natural Resource Management	3		1	0	4	4
	Total Credit Semester II							**24**	

SEMESTER-III (Total Credits =24)

Sr. No.	**Course No**	**Course Code**	**Course Title**	**L**	**T**	**P**	**Hrs/Week**	**Total Credit**
Core Courses								
1	CC 10	SBS GEO 3 3 10 C 3 1 0 4	Advances in GIS and Future Trends	3	1	0	4	4
2	CC 11	SBS GEO 3 3 11 C 3 1 0 4	Advances in Remote Sensing	3	1	0	4	4
3	CC 12	SBS GEO 3 3 12 C 2 0 2 4	Practical 4: Geo-Statistics & Statistical Applications in GIS	2	0	4	6	4
4	CC 13	SBS GEO 3 3 13 C 3 1 0 4	Application of Geoinformatics in Urban Studies	3	1	0	4	4
Discipline Centric Elective Courses (Minimum 8 Credits Required)								
5	DCEC 3	SBS GEO 3 3 0 3 DCEC 3 1 0 4	Application of Geoinformatics for Water Resource Management	3	1	0	4	4

6	DCEC 4	SBS GEO 3 3 0 4 DCEC 3 1 0 4	Application of Geoinformatics in Environmental Management	3	1	0	4	4
7	DCEC 5	SBS GEO 3 3 0 5 DCEC 3 1 0 4	Application of Geoinformatics in Disaster Management	3	1	0	4	4
8	DCEC 6	SBS GEO 3 3 0 6 DCEC 0 4 0 4	Seminar	0	4	0	4	4
9			MOOC 2*	-	-	-	-	4
Total Credit Semester III							**24**	

SEMESTER-IV (Total Credits =24)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credit
1.	CC 14	SBS GEO 3 4 14 C 00024	Dissertation**	-	-	-	-	24
Total Credit Semester IV							**24**	

*MOOC Courses must be related to the subject of Geoinformatics.

******General Guidelines for Students who want to pursue their dissertation outside of the University Campus/Department:

1. The supervisor must be from the parent department. They can choose a co-supervisor from another organisation/institution/department.
2. The co-supervisor must have knowledge or research experience in the field of Geoinformatics.
3. Research institutions/Organisations must have basic facilities such as GPS, GIS/Remote Sensing Lab etc.
4. The Department Council will make the final decision in the aforementioned matter.

8. COURSE-LEVEL LEARNING OUTCOMES:

SEMESTER- I

<table>
<tr><td colspan="2">Course No: CC 1</td><td colspan="5">Course Name: Principles of Remote Sensing</td><td colspan="3">Course Code: SBS GEO 3 1 01 C 3104</td></tr>
<tr><td rowspan="2" colspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td rowspan="2" colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Nil</td></tr>
<tr><td colspan="2">Course Objective</td><td colspan="8">Disseminate basic concepts and applications of Electromagnetic Spectrum in Remote Sensing, and learn about remote sensing platforms, sensors and their characteristics as well as thermal and microwave remote sensing.</td></tr>
<tr><td colspan="2">Course Outcomes:</td><td colspan="8">After completing this course, the student is expected to learn the following:
CO1: To learn the basic concepts of remote sensing.
CO2: To understand the basic difference between various kinds of satellites and sensors.
CO3: To learn the concept and application of thermal and microwave remote sensing.
CO4: To know the significance of image interpretation and remote sensing set-up in India.</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td colspan="2">Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td colspan="2">I</td><td colspan="6">BASIC CONCEPTS
[Course Outcome (s) No.: 1]
Remote Sensing: Concept and Development; Electromagnetic Radiation (EMR) and Spectrum; Interaction of EMR with Atmosphere and Earth’s Surface; Spectral Response and Spectral Signature.</td><td colspan="2">15</td></tr>
<tr><td colspan="2">II</td><td colspan="6">REMOTE SENSING SATELLITES AND SENSORS
[Course Outcome (s) No.: 2]
Satellites and their Characteristics: Geostationary and Sun Synchronous; Weather & Communication Satellites: NOAA, TERRA, MOS, INSAT, GOES; Remote Sensing Systems: Sensor Resolutions and Platforms; Sensor classification: Multispectral and Hyper-Spectral; Sensor Specification of LANDSAT, LISS, CARTOSAT, WiFS, AWiFS, MODIS.</td><td colspan="2">15</td></tr>
</table>

III	**THERMAL & MICROWAVE REMOTE SENSING** **[Course Outcome (s) No.: 3]** Thermal Remote Sensing: Thermal Processes; Imaging Systems and Platforms; Thermal Properties of Materials; Characteristics of TIR Images; Concept and Principles of Microwave Remote Sensing; Microwave Data Sets; Application of Thermal and Microwave Remote Sensing.	15
IV	**IMAGE INTERPRETATION AND REMOTE SENSING SET UP** **[Course Outcome (s) No.: 4]** Image interpretation: Elements of Visual Image Interpretation and Interpretation keys; Remote Sensing Set up in India	15

Suggested Readings:

1. Kumar, D., Singh, R.B., and Kaur, R. (2019). **Spatial Information Technology for Sustainable Development Goals**. Springer Nature, Switzerland.
2. Kron, G. (2017). **Global Navigation Satellite Systems: Signal, Theory & Applications.** Scitus Academics, Wilmington.
3. Chuveico, E. (2016). **Fundamentals of Satellite Remote Sensing — An Environmental Approach** (2nd Edition). CRC Press, Roca Raton.
4. Chaunial, D.D. (2016). **Principles of Remote Sensing and Geographical Information System** (In Hindi), Sharda Pustak Bhawan, Allahabad.
5. Scott, M. (2015). **Global Navigation Satellite Systems and Their Applications.** Springer, New York.
6. Sabins, F.F. (2007). **Remote Sensing: Principles and Interpretation** (3rd Edition). Waveland Press, Long Grove.
7. Chang, K-T. (2006). **Introduction to Geographic Information Systems.** Tata McGraw Hills, New Delhi.
8. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. (2004). **Remote Sensing and Image Interpretation** (5th Edition). John Wiley India, New Delhi.
9. Joseph, G. (2003). **Fundamental of Remote Sensing.** University's Press (India) Pvt. Ltd., Hyderabad.
10. Burrough, P.A. and McDonnell, R.A. (1998). **Principles of Geographic Information Systems.** Oxford University Press, Oxford.

<table>
<tr><td>Course No:
CC 2</td><td colspan="2">Course Name: Principles of GIS & Cartography and GNSS</td><td colspan="6">Course Code: SBS GEO 3 1 02 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">Introduce students to the fundamental concepts of GIS and cartography, as well as spatial data and spatial data creation and organization. This course also teaches various GIS-based approaches and techniques to visualise and solve real-life natural, environmental, and societal problems.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand and explain the basic concepts of GIS.
CO2: Learner will be able to describe various GIS techniques within a spatial analytical framework.
CO3: To understand the principles of GNSS and its applications.
CO4: To learn the concept and scope of cartography.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
I	**INTRODUCTION TO GIS** **[Course Outcome (s) No.:1]** Definition and Development of GIS; Components of GIS; Basic Concepts of Spatial and Non-Spatial Data; Spatial Data Models: Raster and Vector.	15
II	**DATA STRUCTURE & FORMAT** **[Course Outcome (s) No.:2]** Attribute Data in GIS; Types of Attribute Tables; Database Management System; Relational Database Model; Types and Methods of Overlay; Buffering.	15
III	**CONCEPT OF GNSS** **[Course Outcome No.: 3]** Concept & Historical Background of Global Navigation Satellite System (GNSS); Principle; Operation; Segments; Sources of Errors. Applications of GNSS in Cadastral Mapping and g-Governance.	15

IV	**FUNDAMENTALS OF CARTOGRAPHY** **[Course Outcome No.: 4]** Cartography: Concept, Scope & Significance of Cartography; Map Projections: Geographic Coordinate System and Projected Coordinate System; Map-making process: Thematic and Composite mapping; Scale of Measurement: Nominal, Ordinal, Interval and Ratio; Map symbolization.	15

Suggested Readings:

1. Wood, M. (2016). **Cartography the way ahead**. Royal Scottish Geographical Society.
2. Bolstad, P. (2016). **GIS Fundamentals: A First Text on Geographic Information Systems** (4th edition). Eider (PressMinnesota).
3. Monmonier, M. (2015). **The History of Cartography** (Volume 6). University of Chicago Press.
4. Mishra R.P., and Ramesh, A. (2014). **Fundamentals of Cartography** (2nd edition). Prasaranga, University of Mysore.
5. Robinson, A.H., Morrison, J.L., Muehrcke, P.H., Kimerling, A., and Guptill, S.C. (1995) **Elements of Cartography** (6th Edition). Wiley.
6. Chang, K-T. (2007). **Introduction to Geographic Information Systems**. Tata McGraw Hill, New Delhi.
7. Lo, C.P., and Yeung, A.K.W. (2006). **Concepts and Techniques of Geographic Information Systems.** Prentice Hall of India, New Delhi.
8. Burrough, P.A., and McDonnell, R. (1998). **Principles of Geographical Information Systems.** Oxford University Press, New York.
9. Harwell, J. D., & Newson, M. D. (1973). **Techniques in Physical Geography.** Macmillan Edn, Ltd., London.
10. Monkhouse, F. J., & Wilkinson, H. R. (1952). **Maps and Diagrams, their complication and Concentration**. Methuen & Co., London.

<table>
<tr><td colspan="2">Course No: CC 3</td><td colspan="4">Course Name: Introduction of Aerial Photograph and Photogrammetry</td><td colspan="3">Course Code: SBS GEO 3 1 03 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td colspan="2" rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">To understand the fundamental principles and techniques of photogrammetry</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, the student is expected to learn the following:
CO1: To study aerial photography, including types, planning, and execution.
CO2: To investigate various photogrammetric principles and photographic scale.
CO3: Students would be able to understand the concepts of relief displacement and orthorectification.
CO4: Students would be able to understand the concept of stereoscopic viewing and stereoscopic parallax.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV and few topics from Unit II will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">AERIAL PHOTOGRAPHY
[Course Outcome (s) No.: 1]
Introduction to Aerial Photography: Basic Information and Specifications of Aerial Photographs; Flight Planning; Geometric Characteristics of Aerial Photographs; Types of Aerial Photograph; Types of Aerial Camera.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="5">PHOTOGRAMMETRY & PHOTOGRAPHIC SCALE
[Course Outcome (s) No.: 2]
Definitions and Development of Photogrammetry; Classifications of Photogrammetry; Uses of Photogrammetry; Soft-Copy Photogrammetry: Interior Orientation, Exterior Photogrammetry; Concept of Photographic Scale; Methods for Determining Photo Scale.</td><td colspan="3">15</td></tr>
<tr><td>III</td><td colspan="5">RELIEF DISPLACEMENT AND ORTHORECTIFICATION
[Course Outcome (s) No.: 3]
Relief Displacement: Characteristics of Relief Displacement; Object Height Determination from</td><td colspan="3">15</td></tr>
</table>

	Relief Displacement measurement; Orthorectification; Advantages of Orthophotos; Automatic Contouring during Orthophotos Production.	
IV	**STEROSCOPIC VIEWING AND STEREOSCOPIC PARALLAX** **[Course Outcome (s) No.: 4]** Depth Perception; Stereoscopic Depth Perception; Viewing Photographs Stereoscopically; Use of Stereoscope; Stereoscopic Methods of Parallax Measurement: Causes of X and Y Parallax, Stereoscopic Parallax Equation.	15

Suggested Readings:

1. Publication Division. (2016). **India 2016**. Ministry of Information & Bro.
2. James, K. (2016). **Modern Photogrammetary.** Wiley.
3. McGlone, J.C. (2014). **Manual of Photogrammetry (**Seventh Edition). American Society for Photogrammetry and Remote Sensing.
4. Paul, R. W., DeWitt, B.A., and Wilkinson, B.E. (2014). **Elements of Photogrammetry with Applications in GIS** (4th Edition). McGraw-Hill Education.
5. Wolf, P.R., and Dewitt, B.A. (2013). **Elements of Photogrammetry: with Applications in GIS** (5^{th} Ed.). McGraw-Hill.
6. Kasser, M. and Egels, Y. (2012). **Digital Photogrammetry**. Taylor & Francis.
7. Mikail, E.M., Bethel, J.S., and McGlone, J.C. (2011). **Introduction to Modern Photogrammetry.** John Wiley & Sons, Ins.
8. Leberl, F. (2008). **Radar grammetry for Image Interpreters** (2nd Edition). International Institute for Aerial Survey and Earth Sciences, Enschede, The Netherland.
9. Schenk, T. (1999). **Digital Photogrammetry-Vol. 1**.TerraScience. (Main textbook).
10. Greve, C. (1996). **Digital Photogrammetry-An Addendum to the Manual of Photogrammetry.** American Society for Photogrammetry and Remote Sensing.

Course No: CC 4	**Course Name:** Practical- 1: GIS	**Course Code:** SBS GEO 3 1 04 C 2024

Batch:	**Programme:**	**Semester :**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
2022-24 and onwards	M.Sc. Geoinformatics	I	2	0	4	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** Nil

Course Objective	*To become acquainted with and learn about various GIS software and GIS capabilities.*
Course Outcomes:	After completing this course, the student is expected to learn the following: **CO1:** Overview of GIS software and hands-on practices. **CO2:** To know the methods of data creation and topological editing **CO3:** To understand the methods of data analysis, integration, and query. **CO4:** Enables to understand process of GIS models and modelling.

COURSE SYLLABUS

NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.

Unit No.	Content of Each Unit	Hours of Each Unit
I	**INTRODUCTION TO GIS SOFTWARE AND GEOREFERENCING** **[Course Outcome (s) No.: 1]** Overview of GIS software (Commercial & Open Source); Satellite Data Download from USGS and BHUVAN (ISRO); Data Import and Conversion of Analog to Digital format; Georeferencing (Image to Map & Map to Map Transformation).	15
II	**DATA CREATION & TOPOLOGY** **[Course Outcome (s) No.: 2]** Creation of Spatial and Non-Spatial data; Integration of Non-Spatial Data; Topology and Non-Topology Editing.	15
III	**DATA ANALYSIS** **[Course Outcome (s) No.: 3]** Spatial and Non-Spatial Data Query; Overlay; Buffering.	15
IV	**GIS MODELS AND MODELLING**	15

	[Course Outcome (s) No.: 4] Binary Model; Index Model and Regression Model	

Suggested Readings:

1. Lo, C.P., & Yeung, A.K.W. (2009). **Concepts and Techniques of Geographic Information Systems**, (2nd ed.). PHI Learning Pvt. Ltd, New Delhi.
2. Chang, K-T. (2007). **Introduction to Geographic Information Systems**. Tata McGraw Hill, New Delhi.
3. Demers, M.N. (2004). **Fundamentals of Geographic Information Systems** (3RD ed.). Wiley India Pvt. Ltd., New Delhi.
4. Lo. C.P., & Yeung A.K.W. (2004). **Concepts and Techniques of GIS**. Prentice-Hall of India, New Delhi.
5. Agarwal, N.K. (2004). **Essentials of GPS.** Spatial Network Pvt. Ltd.
6. Bernhardsen, T. (2003). **Geographic Information Systems: An Introduction** (3RD ed.). Wiley India Pvt. Ltd., New Delhi.
7. George, J. (2003). **Fundamentals of Remote Sensing**, University Press. Hyderabad
8. Lillesand T.M. and Keifer, R.W. (2000). **Remote Sensing and Image Interpretation** (4th Edition). John Wiley and Sons, New York.
9. Laurini, R., and Thompson, D. (1992). **Fundamentals of Spatial Information Systems.** Academic Press.
10. Maguire, D.J., Goodchild, M.F., Rhind, D.W. (1991). **Geographical Information Systems.** Longman, London, UK.

<table>
<tr><td>Course No: CC 5</td><td colspan="2">Course Name: Practical-2: Cartography and GNSS</td><td colspan="5">Course Code: SBS GEO 3 1 05 C 2024</td></tr>
<tr><td rowspan="2">Batch:
2022-24 and onwards</td><td rowspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 6</td></tr>
<tr><td>2</td><td>0</td><td>4</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course gives emphasis on the art, science, and technology of cartography and GPS. It develops the user's ability to understand how maps are created traditionally and digitally.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, the student is expected to learn the following:
CO1: To understand the basic concept of cartography.
CO2: To learn the thematic cartography and characteristics of geographical phenomena.
CO3: To understand the elements of geographic representation
CO4: To understand the concept of GPS.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">INTRODUCTION TO CARTOGRAPHY
[Course Outcome (s) No.: 1]
Coordinate System; Project from a geographic to a projected coordinate system; Import a coordinate system; Project using a Predefined Coordinate System; Reproject a Coordinate System; Reproject a Raster.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="5">CARTOGRAPHIC REPRESENTATION
[Course Outcome (s) No.: 2]
Cartographic Representation: Spatial Feature and Maps Symbols; Use of Colour; Data Classification;</td><td colspan="2">15</td></tr>
</table>

	Generalisation; Thematic and Composite Mapping; Typography.	
III	**GEOGRAPHIC REPRESENTATION** **[Course Outcome (s) No.: 3]** Map Design: Layout Preparation; Map Production	15
IV	**GLOBAL POSITIONING SYSTEM** **[Course Outcome (s) No.: 4]** Demonstration on GPS; Selection of Datum, Units and Scale; GPS Measurement: Collection of GCPs; Mobile Mapping; Transfer of GPS data into GIS software and Mapping.	15

Suggested Readings:

1. ESRI. (2004). **ESRI Cartography: Capabilities and Trends**. Redlands, CA. White Paper.
2. Pickles, J. (2003). **A History of Spaces: Cartographic Reason, Mapping, and the Geo-Coded World.** Taylor & Francis. ISBN 0-415-14497-3
3. Slocum, T. (2003). **Thematic Cartography and Geographic Visualization.** Upper Saddle River, New Jersey: Prentice Hall. ISBN 0-130-35123-7.
4. Imus, D., and Dunlavey, P. (2002). **Back to the Drawing Board: Cartography vs the Digital Workflow**. MT. Hood, Oregon.
5. Kraak, M-J., and Brown, A. (2001). **Web Cartography – Developments and prospects**. Taylor & Francis, New York, ISBN 0-7484-0869-X.
6. Slocum, T.A. (1999). **Thematic Cartography and Visualization**. Prentice Hall, New Jersey.
7. MacEachren, A.M. (1994). **Some Truth with Maps: A Primer on Symbolization & Design**. University Park: The Pennsylvania State University.
8. Monmonier, M. (1993). **Mapping It Out**. University of Chicago Press, Chicago.
9. Monmonier, M (1991). **How to Lie with Maps**. University of Chicago Press, Chicago. ISBN 0-226-53421.
10. Sircar, D.C.C. (1990). **Studies in the Geography of Ancient and Medieval India**. Motilal Banarsidass Publishers. ISBN 8120806905.

<table>
<tr><td colspan="2">Course No: GE 1</td><td colspan="3">Course Name: Fundamental of Geographic Information System</td><td colspan="4">Course Code: SBS GEO 3 1 01 GE 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-24 and onwards</td><td rowspan="2" colspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester :
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2" colspan="3">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">To understand and learn about the basic ideas behind GIS.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To know the fundamentals of GIS.
CO2: To learn about the GIS database.
CO3: To understand the mapping on GIS platform and Database Management System.
CO4: To understand the concept of GIS applications</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">INTRODUCTION TO GIS
[Course Outcome (s) No.: 1]
Definition and Development of GIS; Components of GIS; Coordinate System; Basic Concept of Spatial and Non-Spatial Data.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="6">GIS DATABASE
[Course Outcome (s) No.: 2]
Spatial Data Model: Raster and Vector; Advantages and limitations of Raster and Vector Data Models; Attribute Data in GIS; Types of Attribute Data.</td><td colspan="2">15</td></tr>
</table>

III	**DATABASE MANAGEMENT SYSTEM AND SPATIAL ANALYSIS** **[Course Outcome (s) No.: 3]** Database Management System: Relational Database Model; Types and Methods of Overlay; Buffering.	15
IV	**APPLICATIONS OF GIS** **[Course Outcome (s) No.: 4]** Applications of GIS in Urban Planning, Health; Crime; Disaster Management; Surveying; Transportation.	15

Suggested Readings:

1. Bolstad, P. (2016). **GIS Fundamentals: A First Text on Geographic Information Systems** (4th edition). Eider Pr.
2. Heywood, I., Cornelisus, S., and Carver, S. (2011). **An Introduction to Geographical Information Systems**. Pearson Education, New Delhi.
3. Chang, K. T. (2008). **Introduction to Geographic Information Systems** Avenue of the Americas, McGraw-Hill, New York Longley.
4. Lo, C.P., and Yeung, A.K.W. (2006). **Concepts and Techniques of Geographic Information Systems.** Prentice Hall of India, New Delhi.
5. Lo, C. P., and Yeung, A. W. (2002). **Concepts Techniques of Geographical Information Systems**. Prentice-Hall of India, New Delhi.
6. Goodchild, M. F., Maguire, D. J., Rhind, D. W. (2002). **Geographical Information Systems and Science**. John Wiley & Sons, Chichester.
7. Korte, G. B. (2001). **The GIS Book**, Onward Press, Bangalore.
8. Burrough, P. A., and McDonnell, R. A. (2000). **Principles of Geographical Information Systems.** Oxford University Press, New York.
9. Demers, M. N. (2000). **Fundamentals of Geographic Information Systems.** John Wiley and Sons, New Delhi.
10. Burrough, P.A., and McDonnell, R. (1998). **Principles of Geographical Information System**s. Oxford University Press, New York.

Course No: GE 2	**Course Name:** Fundamentals of Remote Sensing & Aerial Photograph	**Course Code:** SBS GEO 3 1 02 GE 3104

Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2022-24 and onwards	M.Sc. Geoinformatics	I	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** Nil
Course Objective	*Understanding key concepts of remote sensing and aerial photography*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** To understand aerial photographs and their characteristics. **CO2:** To understand the key concepts in remote sensing. **CO3:** To learn about platforms, sensors, and orbits of satellites. **CO4:** To understand image pre-processing and image enhancement.

COURSE SYLLABUS

NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV and few topics from Unit II will be taught via online mode.

Unit No.	Content of Each Unit	Hours of Each Unit
I	**AERIAL PHOTOGRAPHY** **[Course Outcome (s) No.: 1]** Aerial Photographs: Types, Geometry, Methods of Determining Scale; Flight Planning; Stereoscopes and Stereoscopic Vision; Types and Components of Aerial Cameras.	15
II	**INTRODUCTION TO REMOTE SENSING & INTERACTION OF EMR** **[Course Outcome (s) No.: 2]** Remote Sensing: Concept and Development, Electromagnetic Radiation (EMR) and Spectrum; Interaction of EMR with atmosphere and Earth's Surface.	15
III	**PLATFORMS, SENSORS & ORBITS** **[Course Outcome (s) No.: 3]** Types and Characteristics of Platforms & Satellite Orbits; Sensor Classification: Active and Passive; Multi-spectral scanning: Across and Along Tracking Scanning; Sensors- Types, Specifications and Resolutions (Landsat, LISS and Cartosat).	15

IV	**IMAGE PRE-PROCESSING AND ENHANCEMENT** **[Course Outcome (s) No.: 4]** Concept of Digital Image and Digital Image Processing; Image Enhancement: Histogram, Contrast Enhancement, Filtering; Image Classification.	15

Suggested Readings:

1. James, K. (2016). **Modern Photogrammetary**. wily.
2. Publication Division (2016), **India 2016**. Ministry of Information & Broadcast.
3. McGlone, J.C. (2014). **Manual of Photogrammetry** (Seventh Edition). American Society for Photogrammetry and Remote Sensing.
4. Wolf, P.R., Dewitt, B.A., & Wilkinson, B.E. (2014). **Elements of Photogrammetry with Applications in GIS (**4th Edition). McGraw-Hill Education.
5. Wolf, P.R., and Dewitt, B.A. (2013). **Elements of Photogrammetry: with Applications in GIS** (5^{TH} Ed.). McGraw-Hill.
6. Kasser, M., and Egels, Y. (2012). **Digital Photogrammetry.** Taylor & Francis.
7. Mikail, E.M., Bethel, J.S., and McGlone, J.C. (2011). **Introduction to Modern Photogrammetry.** John Wiley & Sons, Ins.
8. Leberl, F. (2008), **Radar grammetry for Image Interpreters** (2nd Edition). International Institute for Aerial Survey and Earth Sciences, Enschede, The Netherland.
9. Schenk, T. (1999). **Digital Photogrammetry-Vol. 1.** TerraScience. (Main textbook).
10. Greve, C. (1996). **Digital Photogrammetry-An Addendum to the Manual of Photogrammetry**. American Society for Photogrammetry and Remote Sensing.

Course Structure

SEMESTER- II

<table>
<tr><td>Course No: CC 6</td><td colspan="2">Course Name: Spatial Data Modeling and its Application</td><td colspan="5">Course Code: SBS GEO 3 2 06 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-24 and onwards</td><td rowspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge of Geospatial Data, Its differences</td></tr>
<tr><td>Course Objective</td><td colspan="7">Understanding the basics of geo-spatial data. What are the major differences between various geospatial datasets and how they are important in our lives? This paper will cover the modelling and application of geospatial data, preparing students to deal with complex geospatial applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand the concept and principle of spatial data, handling and understanding of the tools to deal with spatial data.
CO2: To understand about the different types of spatial data models and their basic differences.
CO3: To understand about the modeling process of raster and vector data models.
CO4: To understand about the application of the spatial data in our everyday life.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="4">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="4">CONCEPTS AND PRINCIPLE OF SPATIAL DATA MODELS
[Course Outcome (s) No.: 1]
Introduction to Geospatial Data; Importance of Geospatial Data; Handling of Geospatial Data; Overview of the tools for Geospatial Analysis.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="4">SPATIAL DATA MODELS
[Course Outcome (s) No.: 2]
Spatial analysis of Vector Data: Overlay operations: point in polygon, line in polygon, polygon on polygon, Single Layer Operations, Features Identification and extraction, Classification and Manipulation; Multilayer Operations: Union, Intersection, Difference.
Spatial Analysis of Raster Data: Map Algebra; Grid-Based Operations, Local, Focal, Zonal and Global</td><td colspan="3">15</td></tr>
</table>

	Functions, Cost Surface Analysis, Optimal Path and Proximity Search.	
III	**MODELLING PROCESS** **[Course Outcome (s) No. :3]** Modelling of Raster and Vector Data: Network Analysis: Concept of Network Analysis, Types of Network Analysis, Evaluation of Network Complexity Using Alpha, Gama Indices, Network Data Model Point Pattern: Method for Evaluating Point Patterns, Clustered and Random Distribution Surface Analysis: Interpolation Method, DEM, TIN, Variance Filter, Slope and Aspect, Relief and Hill Shading.	15
IV	**APPLICATION OF GEOSPATIAL MODELLING** **[Course Outcome (s) No. :4]** Application of Geospatial Modelling in Land Resource, Water Resource, Disaster Management, Urban Planning and Environmental Management.	15

Suggested Readings:

1. Rahman, A.A., and Pilouk, M. (2008). **Spatial Data Modeling for 3D GIS.** Springer, New York.
2. Chang, K-T. (2007). **Introduction to Geographic Information Systems.** Tata McGraw Hill, New Delhi.
3. Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W. (2005). **Geographic Information Systems and Science** (2nd edition). Chichester: Wiley.
4. Ott, T., and Swiaczny, F. (2001). **Time-integrative GIS. Management and analysis of spatio-temporal data**. Springer Berlin / Heidelberg / New York.
5. Burrough, P.A., and MacDonneli, R.A. (2000). **Principals of GIS**. Oxford University Press.
6. Roy, P.S. (2000). **Geographical Information Science** (Vol. 1). IIRS.
7. Demers, M.N. (2000). **Fundamentals of Geographic Information Systems** (2nd Edition). John Wiley & Sons.
8. Jenson, J.R. (2000). **Remote Sensing of the environment – An Earth Resource Perspective**. Prentice Hall Inc.
9. Malczewski, J. (1999). **GIS and Multi-Criteria Decision Analysis**. New York: John Wiley and Sons.
10. Lillisand, T. M., and Keifer, R. W. (1994). **Remote Sensing and Image interpretation** (3rd edi.). John Willey and Sons, New York.

Course No: CC 7	**Course Name:** Fundamentals of Digital Image Processing	**Course Code:** SBS GEO 3 2 07 C 3104

Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2022-2024 and Onwards	M.Sc. Geoinformatics	II	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** Nil

Course Objective	*This course will introduce fundamental technologies of digital image processing i.e. compression, information extraction and analysis. Students will also gain understanding of algorithm, analytical tools, and practical implementations of various digital image applications.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** To know the Fundamentals of Digital Image Processing. **CO2:** To learn about Image rectification and Restoration. **CO3:** To learn about Image Enhancement Techniques. **CO4:** To understanding the concept of Image classification.

COURSE SYLLABUS

NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.

Unit No.	Content of Each Unit	Hours of Each Unit
I	**FUNDAMENTALS OF DIGITAL IMAGE PROCESSING** **[Course Outcome (s) No.: 1]** Concept of Digital Image and Digital Image Processing; Analog versus digital image; Digital Image Data Format; Image data storage and retrieval.	15
II	**IMAGE RECTIFICATION AND RESTORATION** **[Course Outcome (s) No.: 2]** Pre-Processing: Radiometric and Geometric Errors and corrections; Image Transformation; mosaicking.	15
III	**IMAGE ENHANCEMENT** **[Course Outcome (s) No.: 3]** Image enhancement Techniques: an overview, Image reduction and magnification, Contrast Enhancement: Linear and nonlinear, Band Rationing, Spatial filtering and Edge enhancement, Density slicing, Multi image manipulation: addition, subtraction; Principal Component Analysis; Enhancement by using colours: advantages, Types of colour enhancements; BGR, generation of FCC's, Intensity Hue Saturation (HIS)	15
IV	**IMAGE CLASSIFICATION** **[Course Outcome (s) No.: 4]**	15

	Principles of Image Classification-Image space, Feature space, Image classification; Image Classification process: Preparation for image classification, supervised image classification, unsupervised image classification, classification algorithms, Fuzzy classification; classification based on Object-oriented Image Segmentation.	

Suggested Readings:

1. Lillsand, R.M., and Kiefer, R.W. (1999). **Remote Sensing and Image Interpretation** (4th Ed.). Wiley, New York.
2. Mathur, P.M. (1999). **Computer Processing of Remotely Sensed Images: an introduction.** Wiley, Chichester.
3. Jonson, J.R. (1996). **Introductory Digital Image Processing.** Printice-Hall, Inc.
4. Russ, J.C. (1992). **Image Processing Handbook**. FL: CRC Press. Boca Raton.
5. Jahne, B. (1991). **Digital Image Processing.** Springer-Verlag. New York.
6. Pratt, W.K., (1991). **Digital Image Processing.** 2nd ed., Wiley. New York.
7. Jain, A.K. (1989). **Fundamentals of Digital Image Processing.** Englewood Cliffs, NJ, Prentice Hall.
8. Richards, J.A. (1986). **Remote Sensing Digital Image Analysis.** Springer-Verlag. New York.
9. Mullar, J.P. (1986). **Digital Image Processing in Remote Sensing.** Taylor & Francis.

Schowengerdt, R.A. (1983). **Techniques for image processing and classification in Remote Sensing.** Academic Press. New York.

<table>
<tr><td>Course No:
CC 8</td><td colspan="4">Course Name: Research Methodology and Report Writing</td><td colspan="3">Course Code: SBS GEO 3 2 08 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge of computer, data and data analysis. Basic knowledge of field instruments.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce the students with research methodology. To expose the students to tools and techniques to do fieldwork and obtain data through practical experience in geographical field study. To make the students able to use software for data analysis and to learn the writing and preparation of field report.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand the meaning and significance of research. By knowing about the process of research by doing a literature review and creating a research problem, question, and hypothesis.
CO2: To understand the research design, sampling design, data collection methods, research report writing and ethics.
CO3: To learn the measurement of central tendency, concentration and dispersion
CO4: To develop skills in the conduct of geo-spatial surveys and report writing.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="4">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="4">INTRODUCTION TO RESEARCH
[Course Outcome (s) No.: 1]
Research: Meaning, Objective, Types and Significance and; Research Process; Review of Literature; Formulation of research Problem; Research Question and Hypothesis.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="4">RESEARCH DESIGN AND EHTICS
[Course Outcome (s) No.: 2]
Selection of Research Design; Sampling Design and Determination of Sample Size; Measurement and Scaling Techniques; Methods of Data Collection: Quantitative and Qualitative; Structure and Components of Scientific Reports; Writing of Research Proposal, References and Bibliography, Plagiarism.</td><td colspan="3">15</td></tr>
<tr><td>III</td><td colspan="4">MEASUREMENT OF CENTRAL TENDENCIES, DISPERSION AND CONCENTRATION
[Course Outcome (s) No.:3]</td><td colspan="3">15</td></tr>
</table>

	Measures of Central Tendency: Arithmetic Mean, Median, Mode and their Geographical Significance; Measures of Dispersion and Concentration: Mean Deviation, Standard Deviation; Coefficient of Variation.	
IV	**CONDUCT A GEO-SPATIAL SURVEY AND REPORT WRITING** **[Course Outcome (s) No.:4]** Conduct a Geo-Spatial Survey of any Region with a Structured Methodology/Questionnaire/Schedule; Prepare a Field-Survey Report.	15

Suggested Readings:

1. Gupta, S.P. (2021). **Statistical Methods (46th Edition).** Sultan Chand and Sons.
2. Ahuja, R. (2019). **Research Methods.** Rawat Publication, New Delhi.
3. Kothari, C.R. (2019). **Research Methodology: Methods and techniques**. New Age international Publishers, New Delhi.
4. Healey, J.F. (2018). **Statistics: A tool for social research.** Rawat Publication, Jaipur.
5. Dikshit, R. D. (2003). **The Art and Science of Geography: Integrated Readings**. Prentice-Hall of India, New Delhi.
6. Mukherjee, N. (2002). **Participatory Learning and Action: with 100 Field Methods.** Concept Publs. Co., New Delhi.
7. Kitchin, R., and Tate, N. (2001). **Conducting Research into Human Geography. Theory, Methodology and Practice**. Prentice-Hall, London.
8. Mahmood, A. (1998). **Statistical Methods in Geographical Studies**. Rajesh Publication.
9. Wolcott, H. (1995). **The Art of Fieldwork.** Alta Mira Press, Walnut Creek, CA.
10. Creswell, J. (1994). **Research Design: Qualitative and Quantitative Approaches**. Sage Publications.

<table>
<tr><td>Course No: CC 9</td><td colspan="3">Course Name: Practical 3: Digital Image Processing and Information Extraction</td><td colspan="4">Course Code: SBS GEO 3 2 09 C 2024</td></tr>
<tr><td rowspan="2">Batch:
2022-24 and onwards</td><td rowspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 6</td></tr>
<tr><td>2</td><td>0</td><td>4</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course will introduce fundamental technologies of digital image processing i.e. compression, information extraction and analysis. Students will also gain understanding of algorithm, analytical tools, and practical implementations of various digital image applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand the basic uses of remote sensing and mapping.
CO2: To learn data preparation and its uses.
CO3: To understand the techniques of image enhancement.
CO4: To understand the image classification techniques.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="4">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="4">INTRODUCTION TO REMOTE SENSING SOFTWARE
[Course Outcome (s) No.: 1]
Familiarisation with Remote Sensing Software; Visualisation, Import and Export of Satellite Data in various formats.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="4">DATA PREPARATION
[Course Outcome (s) No.: 2]
Layer Stacking of Multi Spectral Images; Creating Subset of Image; Resolution Merge and Mosaic.</td><td colspan="3">15</td></tr>
<tr><td>III</td><td colspan="4">IMAGE ENHANCEMENT
[Course Outcome (s) No.: 3]
Displaying Individual Pixel Value and Image Information; Image Enhancement Techniques: Image Contrast; Histogram Equalization and Density Slicing; Band Rationing; Filtering Techniques; Principal Component Analysis.</td><td colspan="3">15</td></tr>
<tr><td>IV</td><td colspan="4">IMAGE CLASSIFICATION
[Course Outcome (s) No.: 4]</td><td colspan="3">15</td></tr>
</table>

	Image Classification: Supervised and Unsupervised; Recoding of Pixels; Image Accuracy Assessment and Change Detection.	

Suggested Readings:

10. Lillsand, R.M., and Kiefer, R.W. (1999). **Remote Sensing and Image Interpretation** (4th Ed.). Wiley. New York.
11. Mathur, P.M. (1999). **Computer Processing of Remotely Sensed Images: an introduction.** Wiley, Chichester.
12. Jonson, J.R. (1996). **Introductory Digital Image Processing**. Printice-Hall, Inc.
13. Russ, J.C. (1992). **Image Processing Handbook**. FL: CRC Press. Boca Raton.
14. Jahne, B. (1991). **Digital Image Processing.** Springer-Verlag. New York.
15. Pratt, W.K. (1991). **Digital Image Processing.** 2nd ed., Wiley. New York.
16. Jain, A.K. (1989). **Fundamentals of Digital Image Processing.** NJ, Prentice Hall. Englewood Cliffs.
17. Richards, J.A. (1986). **Remote Sensing Digital Image Analysis.** Springer-Verlag. New York.
18. Mullar, J.P. (1986). **Digital Image Processing in Remote Sensing**. Taylor & Francis.
19. Schowengerdt, R.A. (1983). **Techniques for image processing and classification in Remote Sensing**. Academic Press. New York.

<table>
<tr><td>Course No: DCEC 1</td><td colspan="3">Course Name: Law and Policy for Maps and Remote Sensing Data</td><td colspan="4">Course Code: SBS GEO 3 2 01 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-24 and onwards</td><td rowspan="2">Programme:
M.Sc. Geoinformatics</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of Course: Basic knowledge of map making policies at national and international arena.</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course is intended to develop a comprehensive idea of the evolving laws, policies, and institutions that have long-term ramifications for earth mapping and remote sensing. It also seeks to deal with legal systems, related linkages with land use/cover systems, remote sensing, and map policy. It provides an overall guiding framework for the development and implementation of remotely sensed data to make it useful in geographic information systems at a national and international level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To make laws and policies about maps and remote sensing at both the national and international level.
CO2: To explain the role laws, policies, and institutions play in protecting and managing natural resources.
CO3: To understand the significance of regulations on remote sensing and mapping and their impact on regional and international discourses and debates. It will teach the students about government policies, both macro and micro, to deal with the issues of environmental monitoring and assessment.
CO4: To understand the international laws and policies that govern mapping and remote sensing.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">INTRODUCTION TO LEGAL SYSTEM
[Course Outcome (s) No.: 1]
Mapping the Legal Journey of Geospatial Data: Past to Present; Guidelines issued by Survey of India, Remote Sensing Data Policy (RSDP); Google's Mapathon in Legal Trouble.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="5">RELEVANT LAWS
[Course Outcome (s) No.: 2]
Forest and Wildlife Law: Indian Forest Act, 1927-Legal classification of Forests, Restrictions on the Rights, Wildlife Protection Act 1972, Forest Conservation Act 1980; Land Law: National Land Use Policy; Intellectual Property Law: Relevant to Maps, Information and Data.</td><td colspan="2">15</td></tr>
</table>

III	**NATIONAL LAW AND POLICY ON REMOTE SENSING AND MAPPING** **[Course Outcome (s) No.: 3]** National Drone Policy; The National Geospatial Policy-2016; Geospatial Information Regulations Bill-2016; The National Map Policy-2005; The Remote Sensing Data Policy 2001-2011; National data Sharing and Accessibility Policy-2012.	15
IV	**INTERNATIONAL INSTRUMENTS RELATING TO LAW AND POLICY ON REMOTE SENSING & MAPPING** **[Course Outcome (s) No.: 4]** The Convention on International Liability and Damage caused by Space Objects, 1972; Montreal Convention on International Carriage by Air, 1999; UN Principles relating to Remote Sensing of the Earth from Outer Space.	15

Suggested Readings:

1. Tiwari, N., & Pabreja, H. (2018). **India's Protected Areas: Are They Really Protected or at the Mercy of Wildlife Boards?.** Journal of International Wildlife Law & Policy, 21(1), 23-45.
2. Gogoi, M. (2018). **The Nexus between Sovereignty and 'Eminent Domain'under the Land Acquisition Act, 1894, and the Land Act, 2013**. Social Change, 48(2), 173-187.
3. Sudhakar Reddy et.al., (2015). **Nationwide classification of forest types of India using remote sensing and GIS**. Environmental Monitoring and Assessment 187:777.
4. Ito, A. (2011). **Legal Aspects of Satellite Remote Sensing.** Brill. Pp. 99-147 & 199-241.
5. Adhikari, M. (2011). **Legal Regime of Intellectual Property Rights of Spatial Data with Special Reference to India.** In Geospatial World Forum.
6. Rosencranz, A., & Lele, S.C. (2008). **Supreme Court and India's Forests.** Economic and Political Weekly, 43(5), 11-14.
7. P Jothimani, P., and Venugopal, K. (2002). **GIS Data Dissemination and Intellectual Property Rights**. Indian Cartographer, 336-341.
8. Barr, R. (2001). **Spatial Data and Intellectual Property Rights.** The Map Library in the New Millennium 176-187 (eds Robert Parry & CR Perkins, American Library Association, 2001).
9. Richard West, . (1990). **Copyright Protection for Data Obtained by Remote Sensing: How the Data Enhancement Industry Will Ensure Access for Developing Countries**. Northwestern Journal of International Law & Business, 403-441.
10. Guha, R. (1983). **Forestry in British and Post-British India: A Historical Analysis.** Economic and Political Weekly, 18(44), 1882-1896.

<table>
<tr><td colspan="2">Course No:
DCEC 2</td><td colspan="4">Course Name: Web-GIS</td><td colspan="3">Course Code: SBS GEO 3 2 02 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2" colspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is designed as an introduction to Web GIS, to the programming concepts underlying the construction and implementation of high-quality web mapping applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand the basic concept of web GIS applications.
CO2: Learn about new Web GIS techniques.
CO3: To understand the architecture and services of Web GIS.
CO4: To evaluate the future technologies and perspectives of Web GIS.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">BASIC CONCEPTS
[Course Outcome (s) No.: 1]
Concepts and Principles of Web GIS; Definition and History of Web GIS; Significance of Web GIS; Internet GIS; Open Source GIS; Web Based Geo Portal.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="6">ELEMENTS OF WEB GIS
[Course Outcome (s) No.: 2]
The web as a source of spatial data; Maps on the Web; Querying and Visualizing Geographic Information on the Web; The Web as an integral part of GIS; Geographic Markup Language (GML): GML Features, Application, Visualization and Development of Prototype.</td><td colspan="2">15</td></tr>
<tr><td>III</td><td colspan="6">ARCHITECTURE AND SERVICES OF WEB GIS
[Course Outcome (s) No.: 3]
Architectures for Delivering Web Services-three-tier architecture for web GIS; Interoperability and the Open-GIS Consortium- open web services framework (OSF); Web components- the browser, the server, the hypermedia document and the Uniform Resource Locator</td><td colspan="2">15</td></tr>
</table>

	(URL); presentation and interaction with geographic information on web.	
IV	**WEB SERVICES** **[Course Outcome (s) No.: 4]** Web Map Services (WMS); Web Feature Services (WFS); Catalogue Service on Web (CSW); Web Registry Service (WRS); Web Coverage Service (WCS); Introduction and Scripting in ASP (Active Server Pages)	15

Suggested Readings:

1. Peterson, M.P. (2014). **Mapping in the Cloud**. Guilford Publications.
2. Fu, P. and Sun, J. (2010). **Web GIS: principles and applications**. Esri Press.
3. Chang, K-T. (2008). **Introduction to Geographical Information System** (Fourth Edition). Tata McGraw Hill.
4. Raper, J. (2008). **Mobile GIS: The Arcpad Way.** Esri Pr; Illustrated edition.
5. Drummond, J., Billen, R., João, E., & Forrest, D. (2007). **Dynamic and mobile *GIS***. Boca Raton, FL, CRC Press, Taylor and Francis Group. USA.
6. Billen, R., Joao, E., & Forrest, D. (Eds.). (2006). **Dynamic and mobile GIS: investigating changes in space and time**. CRC Press.
7. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). **Geographic information systems and science.** John Wiley & Sons.
8. Peng, Z. R., & Tsou, M. H. (2003). **Internet GIS: distributed geographic information services for the internet and wireless networks.** John Wiley & Sons.
9. Raper, J. (2000). **Multidimensional geographic information science**. CRC Press.
10. Burrogh, P.A. (1980). **Principles of Geographical Information System for Land Resources Assessment.** Oxford Publications.

<table>
<tr><td>Course No: GE 3</td><td colspan="4">Course Name: Application of Geoinformatics in Disaster Management</td><td colspan="4">Course Code: SBS GEO 3 2 0 3 GE 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic knowledge of disaster and their impacts and how geoinformatics is so important in this field.</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is intended to equip students with a thorough understanding of the concepts of disaster. What various measures are emerging to mitigate its impact? The vulnerability of India to disasters will be examined in this section. Finally, the use of geoinformatics technology in disaster management will be considered.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand the basic concept of different types of natural hazards and disasters, their preparedness and response strategy, and the role of ICT in disaster management.
CO2: To know the role of various stakeholders in planning policies.
CO3: To understand what it means to "recover" and "rehabilitate," as well as the national policy for managing disasters.
CO4: To understand the application of geoinformatics in various important disasters.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">BASIC CONCEPTS
[Course Outcome (s) No.: 1]
Concept of Hazards, Risk, Vulnerability, Disaster and Resilience; Types of disaster: Natural - Flood, Drought, Landslide, Earthquake, and Avalanche; Manmade Disaster – Nuclear, Chemical and Biological.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="5">DISASTER PLAN AND PROGRAMMES
[Course Outcome (s) No.: 2]
Disaster Preparedness: Concept, Plan, Prediction, Early Warning System, Role of ICT, National and International Programmes and Policies, NGOs/Civil Societies; Disaster Responses: Role of Multiple Stockholders, Psychological and Medical Health Responses.</td><td colspan="3">15</td></tr>
<tr><td>III</td><td colspan="5">POST DISASTER PLANNING
[Course Outcome (s) No.: 3]
Reconstruction and Rehabilitation as a Means of Development, Damage Assessment, Long Term Recovery and Counter Disaster Planning</td><td colspan="3">15</td></tr>
</table>

IV	**APPLICATION OF GEOINFORMATICS IN DISASTER MANAGEMENT** **[Course Outcome (s) No.: 4]** Application of Geoinformatics in Disaster Management: Geological Disaster, Hydro-Meteorological Disaster, Environmental Disaster.	15

Suggested Readings:

1. Mishra, A. (2012). **New Dimensions of Disaster Management in India: Perspectives, Approaches and Strategies.** Serials Publications, New Delhi.
2. Chakrabarty, U.K. (2007). **Industrial Disaster Management and Emergency Response**. Asian Books Pvt. Ltd., New Delhi.
3. Sahni, P. et al. (eds.) (2002). **Disaster Mitigation Experiences and Reflections**. Prentice Hall of India, New Delhi.
4. Alexander, D. (2000). **Introduction in Confronting Catastrophe.** Oxford University Press.
5. Parasuraman, S and Unnikrishnan, P.V. (ed.) (2000). **India Disasters Report towards a policy initiative**. Oxford.
6. Sharma, V.K. (1999). **Disaster Management.** National Centre for Disaster management, IIPE, New Delhi.
7. Coch, N.K. (1994). **Geohazards: Natural and Human.** Prentice-Hall, Englewood Cliffs.
8. Smith, K. (1992). **Environmental Hazards: Assessing Risk and Reducing Disaster**. Routledge, London.
9. Carter, W.N. (1991). **Disaster Management: A Disaster Management Handbook.** Asian Development Bank, Bangkok.
10. Nasios, A.S. (1990). **Disaster Mitigation and Economic Incentives. In: Colloquium on the Environment and Natural Disaster Management.** The World Bank, Washington, D.C.

<table>
<tr><td>Course No: GE 4</td><td colspan="5">Course Name: Application of Geoinformatics in Natural Resource Management</td><td colspan="3">Course Code: SBS GEO 3 2 0 4 GE 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is intended to give students the ability to plan, design and execute a GIS project for natural resources management. Its mission is to provide education in the field of geoinformatics for land resources management, aiming towards policy formulation, sustainable development of society and the environment.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand the concept of different natural resource management.
CO2: To learn about land resource management.
CO3: Learn about the application of geo-informatics in water resource management.
CO4: To understand the application of geo-informatics and its integration with forest resource management.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">BASIC CONCEPTS
[Course Outcome (s) No.: 1]
Concept and Classification of Natural Resources; Factors Influencing Resource Availability, Distribution and Uses; Ecological, Social and Economic Dimension of Resource Management; Natural Resources and Development.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="5">LAND RESOURCE MANAGEMENT
[Course Outcome (s) No.: 2]
Lithological Mapping; Structural Mapping and Terrain Analysis; Lineament Extraction; Geo-Hazard Mapping; Mineral Exploration.</td><td colspan="3">15</td></tr>
<tr><td>III</td><td colspan="5">WATER RESOURCE MANAGEMENT
[Course Outcome (s) No.: 3]
Water Quality and Quantity Monitoring and Mapping; Wetland Mapping; Soil Moisture Estimation; Snow Covered Delineation; Flood Mapping; Glacier Dynamics Monitoring; River/Delta Chain Detection; Drainage</td><td colspan="3">15</td></tr>
</table>

	Basin Mapping; Watershed Modelling; Irrigation Canal Leakage Detection.	
IV	**FOREST RESOURCE MANAGEMENT** **[Course Outcome (s) No.: 4]** Reconnaissance Forestry: Forest Cover Type Mapping, Agro-Forestry Mapping; Clear-Cut Mapping/ Deforestation and Regeneration Assessment; Burn Delineation; Biomass Estimation; Species Identification.	15

Suggested Readings:

1. Escalante, R. B. (2012). **Remote Sensing- Advances techniques and Plateforms**. Intech, Rijeka Croatia.
2. Escalante, R. B. (2012). **Remote Sensing Application.** Intech, Rijeka Croatia.
3. Roy, P.S., and Dwivedi, R. S. (2010). **Remote Sensing Application.** www.nrsc.gov.in/Learning-Center, E Book. Html.
4. Joshi, P.K. (2009). **Geoinformatics for Natural Resource Management.** Nova Science Publishers.
5. SPRS Technical Commission VII(2002). **Symposium on Resource Environmental Monitoring.** ISRS Annual Convention, IIRS, Dehradun.
6. Mann, K.H. (2000). **Coastal Ecology & Management, Ecology of Coastal Waters with Implications for Management.** (2nd Edition).
7. Sudershana, R., Mitra, D., Roy, P.S., and Rao, D. P.(2000). **Subtle Issues in Coastal Managemen**t. IIRS, Dehradun.
8. Lal, D. S. (1998). **Climatology.** Chaitanya Publishing House, Allahabad.
9. Deekshatulu, B. L. (1990). **Description and use of Land use/Landcover.** NRSA, Hyedrabad.
10. Harris, J. E. (1990). **Earthwatch – The Climate from space.** Ellishorwood Ltd., Midsower Norton.

Course Structure

SEMESTER- III

<table>
<tr><td>Course No: CC 10</td><td colspan="4">Course Name: Advances in GIS and Future Trends</td><td colspan="4">Course Code: SBS GEO 3 3 10 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester :

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course is designed to introduce Web GIS, programming concepts for constructing high quality web mapping applications, participatory GIS, mobile GIS and the fundamental concepts behind the Internet of Things.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand the recent trends in geo-informatics
CO2: To learn about spatial decision analysis.
CO3: To understand artificial intelligence using machine learning and deep learning.
CO4: To learn about the emerging branches and future trends of geo-informatics.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="6">RECENT TRENDS IN GEO-INFOMATICS

[Course Outcome (s) No.: 1]
Interoperability and Web GIS: Concept and Applications; Mobile GIS- Concepts, Portable PCs, Personal Digital Assistance (PDAs) or Palm Top, Mobile Phone, Arc GIS for Mobile, Characteristics, Significance and Applications of Mobile GIS.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="6">SPATIAL DECISION ANALYSIS
[Course Outcome (s) No.: 3]
Spatial Decision: Analysis and Fuzzy Logic Multi-Criteria Decision Analysis, Estimation of Weights. Analytic Hierarchy Process (AHP), Fuzzy Logic, Operations on Fuzzy Sets, Fuzzy Vs. Boolean, Errors and uncertainty analysis.</td><td colspan="2">15</td></tr>
<tr><td>III</td><td colspan="6">GEO-SPATIAL ANALYSIS USING MACHINE LEARNING AND DEEP LEARNING
[Course Outcome (s) No.: 4]</td><td colspan="2">15</td></tr>
</table>

	Introduction to Machine Learning and Deep Learning; Types and Uses of ML and DL Classifier; Basics of Python; ML and DL Softwares; Application of ML and DL Techniques.	
IV	**EMERGING BRANCHES AND FUTURE TRENDS [Course Outcome (s) No.: 2]** Emerging Branches of GIScience: Geo-Informatics; Hydro-Informatics; Weather-Informatics; Biodiversity-Informatics, and Socio-Informatics; Web Based GIS; Location Based Services and GIS; Volunteer GIS; Cloud GIS; Big Data Analysis; Future Trends of GIScience and Challenges.	15

Suggested Readings:

1. Bolstad, P. (2016). **GIS Fundamentals: A First Text on Geographic Information Systems** (4th edition). Eider (PressMinnesota).
2. McEwen, A., & Cassimally, H. (2013). **Designing the internet of things**. John Wiley & Sons.
3. Heywood, I., Cornelisus, S., Carver, S. (2011). **An Introduction to Geographical Information Systems.** Pearson Education, New Delhi.
4. Chang, K. T. (2008). **Introduction to Geographic Information Systems**. Avenue of the Americas, McGraw-Hill, New York Longley.
5. Weiner, D., & Harris, T. M. (2008). **Participatory geographic information systems**. The handbook of geographic information science, 466-480.
6. Peng, Z. R., & Tsou, M. H. (2003). **Internet GIS: distributed geographic information services for the internet and wireless networks**. John Wiley & Sons.
7. Lo, C. P., Yeung, A. W. (2002). **Concepts Techniques of Geographical Information Systems**, Prentice-Hall of India, New Delhi.
8. Goodchild, M. F., Maguire, D. J., Rhind, D. W. (2002). **Geographical Information Systems and Science.** John Wiley & Sons, Chichester.
9. Demers, M. N. (2000). **Fundamentals of Geographic Information Systems**. John Wiley and Sons, New Delhi.
10. Burrough, P. A. and McDonnell, R. A. (2000). **Principles of Geographical Information Systems.** Oxford University Press, New York.

<table>
<tr><td>Course No:
CC 11</td><td colspan="3">Course Name: Advances in Remote Sensing</td><td colspan="4">Course Code: SBS GEO 3 3 11 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic Knowledge of Geoinformatics, Physical Sciences and Mathematics.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course is aimed at exposing the students to advanced remote sensing and data collection technologies, understand their concepts, principles and applications in various applied scenarios.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To comprehend the concept, theory, and operation of thermal remote sensing.
CO2: To understand the concept, principle, and operation of microwave remote sensing.
CO2: To learn about the concept, principles and workings of hyperspectral remote sensing.

CO4: To understand the application of LIDAR and UAV in geospatial studies.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">THERMAL REMOTE SENSING
[Course Outcome (s) No.: 1]
Introduction to Thermal Remote Sensing; Interaction of Thermal Radiation with Terrain Elements; Thermal Remote Sensing Data Products; Thermal Scanners and Temperature Mapping, Characteristics of Thermal IR Images and Factors Affecting Thermal Images; Thermal Data Interpretation: Qualitative and Quantitative; Applications of Thermal Remote Sensing.</td><td colspan="2">15</td></tr>
<tr><td>II</td><td colspan="5">MICROWAVE REMOTE SENSING
[Course Outcome (s) No.: 3]
Fundamentals of Microwave Remote Sensing; Interactions between Microwaves and Surface Objects: Complex Dielectric Properties, Roughness, Polarization; SLAR: System Components, Spatial Resolution, Synthetic Aperture Radar (SAR), Geometric Characteristics and Interpretation of SLAR imagery; Passive Microwave Remote Sensing: Passive</td><td colspan="2">15</td></tr>
</table>

	Microwave Scanner, Application of Microwave Remote Sensing.	
III	**HYPERSPECTRAL REMOTE SENSING** **[Course Outcome (s) No.: 2]** Basic Principles of Spectroscopy; Hyperspectral Sensors and Platforms; Hyperspectral Data Processing: Geometric and Atmospheric Corrections, End Member Collection, Image Classification; Advantages of Hyperspectral Remote Sensing; Application in Agriculture, Water, Soil and Mineral Resource Mapping.	15
IV	**LIDAR AND UAV** **[Course Outcome (s) No.: 4]** LIDAR: Principles and Components; Terrestrial and Bathymetric Laser Scanner; LIDAR Data Analysis; Applications of LIDAR in Topographic, Vegetation, Urban and Coastal Mapping. Introduction to UAV; Structural Design of UAV**;** Operational Procedure: Assembling the Drone, Preparation of Flight Planning, Data Collection, Data Transfer and Analysis (Use of Drone instrument); Applications of UAV Remote Sensing.	15

Suggested Readings:

1. George, J. (2003). **Fundamentals of Remote Sensing**. Universities Press.
2. Jensen, J.R. (2000). **Remote Sensing of the Environment: An Earth resource Perspective.** Prentice Hall.
3. Mathur, P.M. (1999). **Computer Processing of Remotely Sensed Images: an introduction.** Wiley, Chichester.
4. Pratt, W.K. (1991). **Digital Image Processing** (2nd ed.), Wiley, New York.
5. Jahne, B. (1991). **Digital Image Processing.** Springer-Verlag, New York.
6. Jain, A.K. (1989). **Fundamentals of Digital Image Processing.** Englewood Cliffs, NJ, Prentice Hall.
7. Lillesand, T.M., and Kieffer, R.M. (1987). **Remote Sensing and Image Interpretation**. John Wiley.
8. Mullar, J.P. (1986). **Digital Image Processing in Remote Sensing.** Taylor & Francis.
9. Richards, J.A. (1986). **Remote Sensing Digital Image Analysis.** Springer-Verlag, New York.
10. Sabbins, F.F., (1985). **Remote Sensing Principles and Interpretation**. W. H. Freeman and company.

<table>
<tr><td colspan="2">Course No: CC 12</td><td colspan="3">Course Name: Practical-4: Geo-Statistics and Statistical Applications in GIS</td><td colspan="4">Course Code: SBS GEO 3 3 12 C 2024</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td colspan="2" rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester :

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 6</td></tr>
<tr><td>2</td><td>0</td><td>4</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course teaches Geostatistics and Geographic Information Systems (GIS) concepts and techniques with special skills in spatial information management, analysis, interpretation, map generation and display using advanced Geostatistics and GIS software packages.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To develop an idea to compile, categorize and combine GIS and geostatistical tools to solve in-situ environmental problems.
CO2: To make students able to create, devise, restructure and relate various data components to produce a map.
CO3: To comprehend the statistical techniques used to correlate demographic data.
CO4: To know about the time series model in Geo-Statistics and Statistical Applications in GIS</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="3">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">BASIC CONCEPT OF GEO-STATISTICS
[Course Outcome (s) No.: 1]
Introduction to Geostatistics; Descriptive statistics; Graphical analysis; Geometric Transformation; Spatial Data Editing; Attribute Data Input and Management; Data Display and Cartography; Data Exploration - Correlation and Regression, Vector Data Analysis, Raster Data Analysis.</td><td colspan="3">15</td></tr>
<tr><td>II</td><td colspan="5">SPATIAL ANALYSIS MODELING
[Course Outcome (s) No.: 2]
Proximity – Buffer; Topography - Digital Elevation Model, Slope, Aspect, Hill shade, and View shed; Watershed and Morphometric Analysis; Network analysis; Interpolation and Extrapolation – Kriging, IDW, Spline, Trend, Natural neighbor, Thiesson polygon.</td><td colspan="3">15</td></tr>
</table>

III	**SPATIAL STATISTICAL TECHNIQUES** **[Course Outcome (s) No.: 3]** Regression and Correlation: Linear Regression and Correlation, Multiple Correlations, Multiple Correlation Co-Efficient, Standard Error of Estimate, Curvilinear Regression-Applications; Analysis of Variance-Completely Randomized Designs and Randomized Block Designs.	15
IV	**TIME SERIES MODELS** **[Course Outcome (s) No.: 4]** Components of Time Series, Measuring Forecasting Accuracy – Testing Of ARIMA Models; Multivariate Analysis: Co-Variance Matrix, Correlation Matrix, Multivariate Normal Density Function **(Use of SPSS Software).**	15

Suggested Readings:

1. Johnson, R. A., Miller, I., & Freund, J. E. (2000). P**robability and Statistics for Engineers.** Prentice Hall of India.
2. Johnson, D.E. (2002). **Applied multivariate methods for data analysis.** Thomson & Duxbburg Press, Singapore.
3. Devore, J.L. (2002). **Probability and statistics for Engineering and Sciences**. Thomson and Duxbburg Press, Singapore.
4. Johnson, R.A., and Wichern, D.W. (2002). A**pplied multivariate statistical analysis**. Pearson Education.
5. Burrough, P. A. and McDonnell, R. (1998). **Principles of Geographical Information Systems.** Oxford University Press, New York.
6. Benjamin J. R., and C.Allin, C. (1997). **Probability Statistics and Decision for Civil Engineers.** Mc-Graw Hill.
7. Laurini, R., and Thompson, D. (1992). **Fundamentals of Spatial Information Systems**. Academic Pr., London.
8. House, W.C. (1983). **Decision Support Systems**, Petrocelli, New York.
9. Bonczek, R.H., C.W. Holsapple, and A.B. Whinston, (1981). **Foundations of Decision Support Systems.** Academic Press, New York. Basic text on DSS.
10. Gupta, S.C., and Kapoor V.K. (1978). **Fundamentals of Mathematical Statistics**. Sultan Chand and Sons.

Course No: CC 13	**Course Name:** Application of Geoinformatics in Urban Studies				**Course Code:** SBS GEO 3 3 13 C 3104		
Batch:	**Programme:** M.Sc. Geoinformatics	**Semester:** III	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Basic Knowledge of Geoinformatics.					
Course Objective	*This course specifically aims to build the basic knowledge in the field of urban studies, especially through the use of remote sensing and GIS.*						
Course Outcomes:	After completing this course, the student is expected to learn the following: **CO1:** To know the key concepts of urban studies. **CO2:** To learn about the urban program, planning and policy issues. **CO3:** To understand the remote sensing data in urban mapping. **CO4:** To know the application of remote sensing and GIS in urban planning and management.						

COURSE SYLLABUS

NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.

Unit No.	Content of Each Unit	Hours of Each Unit
I	**BASIC CONCEPTS** **[Course Outcome (s) No.: 1]** Classification of Urban Places in India; Aspects of Urban Places: Definition and Significance of Location, Site and Situation; Concepts of Megacities; Global Cities; Edge Cities, Satellite Towns and Rural-Urban Fringe.	15
II	**URBAN PLANNING AND PROGRAMMES** **[Course Outcome (s) No.: 2]** Concept of Urban Planning; Urban E-Governance; Urban Development Programmes: Smart Cities, AMRUT, HARIDAY, JNNURM, Satellite Towns.	15
III	**REMOTE SENSING DATA FOR URBAN MAPPING** **[Course Outcome (s) No.: 3]** Remote Sensing Data in Urban Studies: Scale, Resolution, Scope and Limitations; Urban Land use/land cover classification; Visual and Digital	15

	Techniques; Change Detection; Sprawl Detection and Characterization; Mapping of Urban Morphology.	
IV	**APPLICATION OF GEOINFORMATICS** **[Course Outcome (s) No.: 4]** Role of Geoinformatics in Plan Formulation; Urban Solid Waste Management; Air quality indexing and mapping; Utility Network Planning and Management, Geoinformatics for Smart Cities.	15

Suggested Readings:

1. Bansal, S.C. (2019). **Urban Geography.** Meenakshi Publication, Meerut.
2. Short, J.R. (2017). **An Introduction to Urban Geography**. Oxford: Routledge.
3. Bhatta, B. (2010). **Analysis of Urban Growth and Sprawl from Remote Sensing Data** (1st Edition). Springer-Verlag.
4. Rashed, T., Carsten, J. (2010). **Remote Sensing of Urban and Suburban Areas (**1st Edition**).** Springer.
5. Netzband, M., Stefanov, W.L., Redman, C. (2007). **Applied Remote Sensing for Urban Planning, Governance and Sustainability (**1st Edition**).** Springer.
6. Fletcher, R. (2007). **The Limits of Settlement Growth: A Theoretical Outline.** (New Studies in Archaeology) (First edition), Cambridge University Press.
7. Weng, Q., & Quattrochi, D. A. (2018). Urban remote sensing. CRC press.
8. Donnay, J. P., Barnsley, M. J., & Longley, P. A. (2005). **Remote sensing and urban analysis (**1st Edition. Taylor and Francis e-Library.
9. Ramachandran, R. (2005). **Urbanization and Urban Systems in India**. Oxford University Press.
10. Longley, P., and Batty, M. (1997). S**patial Analysis: Modeling in a GIS Environment.** Wiley.

<table>
<tr><td>Course No:
DCEC 3</td><td colspan="3">Course Name: Application of Geoinformatics in Water Resource Management</td><td colspan="4">Course Code: SBS GEO 3 3 0 3 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic Knowledge of Rs and GIS, Hydrology and Resource Management.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course will equip the students with the necessary knowledge of hydrological environments and dynamics in order to understand, apply and plan the usage, exploration, and sustainable management of the earth's water resources.</td></tr>
</table>

<table>
<tr><td>Course Outcomes:</td><td colspan="2">After completing this course, student is expected to learn the following:
CO1: To understand the concepts related to hydrology and water resources.
CO2: To acquire knowledge of hydrological processing using remote sensing data and GIS.
CO3: To learn about the exploratory studies aimed at water resource tapping, specifically the groundwater and fluid surface water.
CO4: To learn about exploratory studies aimed at water resource extraction, specifically resources sourced from snow and glaciers.</td></tr>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td colspan="3">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>I</td><td>BASIC CONCEPTS
[Course Outcome (s) No.: 1]
Hydrologic Cycle: Global Scale Model, Watershed Scale Model; Water Resources; Water Balance studies: Precipitation, Interception, Infiltration, Porosity and Permeability, Soil Moisture, Evaporation, Run-off and Discharge; Estimation of Hydrological Parameters using RS & GIS; Run-off Hydrology; Groundwater Hydrology; Introduction to Hydro-informatics.</td><td>15</td></tr>
<tr><td>II</td><td>WATERSHED MANAGEMENT
[Course Outcome (s) No.: 2]
Hydrological Modeling with Geospatial Inputs; Digital Elevation Model (DEM) Hydro-processing; Drainage Morphometry; Watershed Characterization; Watershed Delineation and Codification; Runoff estimates from watersheds & GIS database for watershed management; Watershed Prioritization using Geoinformatics.</td><td>15</td></tr>
<tr><td>III</td><td>WATER RESOURCE EXPLORATION
[Course Outcome (s) No.: 3]
Surface and Sub-surface Water Exploration using Geoinformatics; Water harvesting structures and optimum site selection for rain-water harvesting; Hydro-geomorphological Interpretation for Groundwater Exploration; Groundwater resources estimation and production; Water Quality Modeling and Monitoring using RS and GIS.</td><td>15</td></tr>
</table>

<table>
<tr><td>IV</td><td>SNOW AND GLACIER
[Course Outcome (s) No.: 4]
Snow Cover Mapping in visible spectrum, Middle Infrared and Microwave Regions; Glacier Mapping; Glacier Monitoring and Glacier Run-off Modeling. Dynamics in Glacial Mass-balance.</td><td>15</td></tr>
</table>

Suggested Readings:

1. Reddy, M.A. (2004). **Geoinformatics for Environmental Management.** B.S. Publications.
2. Murty, J.V.S. (2004). **Watershed management.** New Age International Pvt Ltd, New Delhi.
3. Rajora, R. (2003). **Integrated Watershed Management.** Rawat Publication.
4. Skidmore, A. (2002). **Environmental Modeling with GIS and Remote Sensing.** Taylor and Francis.
5. Ebgman, E.T., and Gurney, R.J. (1991). **Remote sensing in hydrology.** Chapman and Hall, London.
6. Gupta, R.P. (1990). **Remote Sensing Geology**. Springer Verlag.
7. Chow, V.T. (1988). **Advances in Hydro Science.** McGraw Hill.
8. Karanth, K.R. (1987). **Groundwater Assessment-Development and Management.** Tata McGraw Hill.
9. Paine, D.P. (1981). **Aerial Photography and Image Interpretation for Resource Management**. John Wiley.
10. Todd, D.K. (1980). **Groundwater Hydrology.** John Wiley.

<table>
<tr><td>Course No:
DCEC 4</td><td colspan="4">Course Name: Application of Geoinformatics in Environmental Management</td><td colspan="4">Course Code: SBS GEO 3 3 0 4 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2022-24 and onwards</td><td rowspan="2">Programme:

M.Sc. Geoinformatics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic Knowledge of Geoinformatics, and Geographical and Environmental Studies.</td></tr>
<tr><td>Course Objective</td><td colspan="8">The course is aimed at equipping the basic knowledge of environmental issues and resolution strategies, and applied knowledge of modern geoinformatics-based methodologies in environmental management.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: To understand about the concepts related to environment and working relationships in the domain of environmental studies.
CO2: To develop an idea about the role of RS and GIS in land and water resource management.
CO3: The know about the role of geoinformatics in air pollution and impact assessment studies.
CO4: To understand the applied aspects of geoinformatics in the field of disaster management.</td></tr>
</table>

COURSE SYLLABUS		
NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**ENVIRONMENT AND ECOLOGY** **[Course Outcome (s) No.: 1]** Ecosystems: Introduction, Types, Structure and Functions; Energy resources; Renewable and Non-renewable Energy Sources; Use of Alternative Energy; Impact of Energy Use on Environment; Environmental Management: Concept and Principles.	15
II	**GEOINFORMATICS BASED STUDIES OF LAND AND WATER RESOURCES** **[Course Outcome (s) No.: 2]** Land/Soil Quality Analysis: Degradation Mapping; Desertification mapping; Soil Erosion and Deposition Modeling; Land Capability Maps; Conservation Measures. Water Resource Studies: Siltation estimation and mapping; Water quality index mapping; Eutrophication and water vegetation mapping; Groundwater: Quality, potential zones, vulnerability, contamination studies.	15
III	**ATMOSPHERIC STUDIES, IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN (EMP)** **[Course Outcome (s) No.: 3]** Atmospheric Pollution Studies: Aerosol remote sensing, air quality indexing and mapping; Spread and dispersion of smoke plumes from industries and power plants, forest fires, and oil wells. Environmental Impact Assessment (EIA); Environmental Monitoring for Sustainable Development using Geoinformatics; EIA of Mining Areas and River Valley Project through Remote Sensing; GIS and Environmental management plan (EMP).	15
IV	**DISASTER MANAGEMENT** **[Course Outcome (s) No.: 4]** Natural and Man-made Disasters; Disaster management cycle and role of remote sensing and GIS in disasters management; Application of Remote sensing and GIS in hazard zonation mapping, preparation and mitigating strategies; GIS-based planning of disaster response; Remote sensing and GIS application in post disasters recovery.	15

Suggested Readings:

1. Shukla, S. (2014). **Vulnerability and Risk Measurement of Climate Induced Disasters in Gujarat.** Academic Foundation, New Delhi.
2. Reddy, M.A. (2004). **Geoinformatics for Environmental Management**. B.S. Publications.
3. Skidmore, A. (2002). **Environmental Modeling with GIS and Remote Sensing**. Taylor and Francis.
4. Jensen, J. R. (2000). **Remote Sensing of the Environment: An Earth Resource Perspective**. Prentice Hall.
5. Bell, F.G. (1999). **Their assessment, avoidance and mitigation**. E & FN SPAN, Routledge, London.
6. George, G., and Kappos, A. J. (1997). **Earthquake Resistant concrete Structures**. E & FN SPAN, London.
7. Lilliesand, T.M., and Kiefer, R, W. (1994). **Remote Sensing and Image Interpretation.** John Wily and sons.
8. Lintz, J., and Simonet, P. (1994). **Remote Sensing of Environment**. Addison Wesley Publishing Company.
9. Alexander, D. (1993). **Natural Disasters.** UCL Press, London.
10. **Geocoded Satellite Images**, John & Wiley Sons, New Delhi.

Course No: DCEC 5	**Course Name:** Application of Geoinformatics in Disaster Management				**Course Code:** SBS GEO 3 3 0 5 DCEC 3104		
Batch: 2022-24 and onwards	**Programme:** M.Sc. Geoinformatics	**Semester:** II	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Basic knowledge of disaster and their impacts and how geoinformatics is so important in this field.					
Course Objective	*This course is intended to equip students with a thorough understanding of the concepts of disaster. What various measures are emerging to mitigate its impact? The vulnerability of India to disasters will be examined in this section. Finally, the use of geoinformatics technology in disaster management will be considered.*						
Course Outcomes:	After completing this course, student is expected to learn the following: CO1: To understand the basic concept of different types of natural hazards and disasters, their preparedness and response strategy, and the role of ICT in disaster management. CO2: To know the role of various stakeholders in planning policies. CO3: To understand what it means to "recover" and "rehabilitate," as well as the national policy for managing disasters. CO4: To understand the application of geoinformatics in various important disasters.						

COURSE SYLLABUS		
NOTE: Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit IV will be taught via online mode.		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**BASIC CONCEPTS** **[Course Outcome (s) No.: 1]** Concept of Hazards, Risk, Vulnerability, Disaster and Resilience; Types of disaster: Natural - Flood, Drought, Landslide, Earthquake, and Avalanche; Manmade Disaster – Nuclear, Chemical and Biological.	15
II	**DISASTER PLAN AND PROGRAMMES** **[Course Outcome (s) No.: 2]** Disaster Preparedness: Concept, Plan, Prediction, Early Warning System, Role of ICT, National and International Programmes and Policies, NGOs/Civil Societies; Disaster Responses: Role of Multiple Stockholders, Psychological and Medical Health Responses.	15
III	**POST DISASTER PLANNING** **[Course Outcome (s) No.: 3]** Reconstruction and Rehabilitation as a Means of Development, Damage Assessment, Long Term Recovery and Counter Disaster Planning	15
IV	**APPLICATION OF GEOINFORMATICS IN DISASTER MANAGEMENT** **[Course Outcome (s) No.: 4]** Application of Geoinformatics in Disaster Management: Geological Disaster, Hydro-Meteorological Disaster, Environmental Disaster.	15

Suggested Readings:

1. Mishra, A. (2012). **New Dimensions of Disaster Management in India: Perspectives, Approaches and Strategies.** Serials Publications, New Delhi.
2. Chakrabarty, U.K. (2007). **Industrial Disaster Management and Emergency Response**. Asian Books Pvt. Ltd., New Delhi.
3. Sahni, P. et al. (eds.) (2002). **Disaster Mitigation Experiences and Reflections**. Prentice Hall of India, New Delhi.
4. Alexander, D. (2000). **Introduction in Confronting Catastrophe.** Oxford University Press.
5. Parasuraman, S., and Unnikrishnan, P.V. (ed.) (2000). **India Disasters Report towards a policy initiative**. Oxford.
6. Sharma, V.K. (1999). **Disaster Management.** National Centre for Disaster management, IIPE, New Delhi.
7. Coch, N.K. (1994). **Geohazards: Natural and Human.** Prentice-Hall, Englewood Cliffs.
8. Smith, K. (1992). **Environmental Hazards: Assessing Risk and Reducing Disaster.** Routledge, London.
9. Carter, W.N. (1991). **Disaster Management: A Disaster Management Handbook**. Asian Development Bank, Bangkok.
10. Nasios, A.S. (1990). **Disaster Mitigation and Economic Incentives. In: Colloquium on the Environment and Natural Disaster Management**. The World Bank, Washington, D.C.

9. TEACHING-LEARNING PROCESS:

Teaching - learning process is aimed at capacitating learners to achieve the determined learning results corresponding to the courses of programmes. This may include lectures followed by Q&A session or group discussion, practical work, use of prescribed textbooks, electronic resources and other self-study materials, project work, which may be individual or team-based, activities devoted to subject-specific and interdisciplinary skills development, internship and visits to industrial or other research facilities etc.

The result-based method, especially in the frame of Master's programme in geography, expects an important change from teacher-centric to learner-centric education and from passive to participatory instructions. Preparation for teaching comes to be crucial. Practical abilities, together with realization of interconnection between theory and experimentation, make up a significant phase of the teaching-learning method. Teaching plans, directed by such a framework, consist of lectures assisted by tutorials; field-based education; use of prescribed reading materials and other self-study materials; project work, some of which may be team-based; activities conceived to serve the development of subject related abilities; internship and visits to field sites, and other research means.

The faculty should promote learning on a proportionate scale of including lectures (listening/hearing), laboratory (scientific analysis and experiments) and field-based (collecting/participating). In order to achieve its objective of focused process based learning and holistic development, a variety of knowledge delivery methods will be used like:

- Lectures
- Discussions
- Hands-On
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

10. IMPLEMENTATION OF BLENDED LEARNING:

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasises student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimises and compliments the face-to-face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- Student-Centric Pedagogical Approach focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;

- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, be adopted

11. ASSESSMENT AND EVALUATION:

A variety of assessment methods that are appropriate within a given disciplinary area and a programme of study will be used. Priority will be accorded to formative assessment. Learning outcomes will be assessed using techniques such as the following: time-constrained examinations, closed-book and open-book tests, problem-based assignments, practical assignments, laboratory reports, observation of practical skills, individual project reports (case study reports), team project reports, oral presentations, seminar presentation, viva voce interviews, computerized adaptive testing, peer and self-assessment, etc. For Geography course the methods of assessment shall include the following:

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. KEYWORDS

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. REFERENCES

1. https://www.terisas.ac.in/msc-geoinformatics.php
2. https://sig.ac.in/msc-in-geoinformatics
3. https://ieer.bharatividyapeeth.edu/index.php/programs-and-courses/msc-geoinformatics
4. http://cuj.cuj.ac.in/LRMDepartment.php
5. http://www.ignou.ac.in/upload/programme/PGCGI%20Programme%20Guide%20Jan2015_ver2.1.pdf
6. https://www.bitmesra.ac.in/UploadedDocuments/deanugpg/files/M_SC_Geoinformatics-Syllabus.pdf
7. https://www.ruraluniv.ac.in/includes/academics/programmes/syllabus/318.pdf
8. https://makautwb.ac.in/syllabus/PG_Diploma_in_Geoinformatics_Syllabus.pdf

14. APPENDICES

DEPARTMENT OF PHYSICS & ASTROPHYSICS

Central University of Haryana

Minutes of the meeting

08 August 2022

A meeting of the Board of Studies (BoS) of the Department of Physics and Astrophysics, Central University of Haryana was held on 08.08.2022 (Monday) at **11:30 AM** in the office of Head, Department of Physics and Astrophysics, Central University of Haryana. The following members were present in the meeting:

1. Prof. Sunita Srivastava, Professor, Department of Physics and Astrophysics, CUH
2. Prof. Suneel Kumar, Head, Department of Physics and Astrophysics, CUH **(Chair)**
3. Dr. Rakesh Kumar, Assistant Professor, Department of Physics and Astrophysics, CUH
4. Prof. R.K. Moudgil, Professor, Department of Physics, Kurukshetra University **(online)**
5. Prof. Ghan Shyam Singh Saini, Professor, Department of Physics, Panjab University

Agenda of the meeting:

To discuss the scheme, structure, and syllabus of

- Integrated B.Sc. M.Sc. (Physics)
- Ph.D. (Physics) course work
- M.Sc. (Physics)

Prof. Suneel Kumar welcomed the members of the Board of Studies (BoS) of the Department of Physics and Astrophysics and informed them about the five-year program of Integrated B.Sc. M.Sc. (Physics), introduced by the department from the session 2021-22. He informed the members that the syllabus for this program is designed considering the implementation of the New Education Policy (NEP-2020) based on the Choice Based Credit System (CBCS) and Learning Outcomes-based Curriculum Framework (LOCF) as recommended by UGC, New Delhi. After thorough deliberation, it was unanimously decided to make the following changes in the syllabus of five-year Integrated B.Sc. M.Sc. (Physics):

1. To improve the competitive skills of the students and to acquire a better understanding of the concept, it was decided to include up to 40% of numerical-based questions in the end-semester examination.
2. To enhance the experimental electronics skills of the students, it was decided to add a new skill enhancement course (SEC) of Electronics Workshop Skills.
3. To rectify the name and code of the course "Computer Programming [SBS PHY 03 304 CC 2024]" to "Introduction to Computer Programming [SBS PHY 03 304 CC 2044]".

SKumar

In the syllabus of two-year M.Sc. (Physics), the revised contents of the syllabus of Classical Electrodynamics was approved unanimously by the BoS. The minor correction in the course codes of the Quantum Mechanics II, Laboratory II and Laboratory III was approved unanimously by the BoS.

After thorough deliberation, it was unanimously decided to make the following changes in the syllabus of Ph.D. (Physics) to add the topic of Characterization Techniques in the course of "Nanotechnology and Ion beam".

In the end, the meeting was concluded with thanks to all the BoS members.

Prof. R.K. Moudgil	Prof. Ghan Shyam Singh Saini	Dr. Rakesh Kumar

Prof. Sunita Srivastava	Prof. Suneel Kumar

विभागाध्यक्ष / Head of the Department
भौतिकी और खगोल भौतिकी विभाग
Department of Physics & Astrophysics
हरियाणा केंद्रीय विश्वविद्यालय
Central University of Haryana
महेंद्रगढ़-123031/ Mahendergarh-123031

Dean School Of Basic Sciences <deansobs@cuh.ac.in>

School Board Meeting on 12-09-2022 at 10:30 A.M. onwards

Dean School Of Basic Sciences <deansobs@cuh.ac.in> Wed, Sep 14, 2022 at 12:34 PM
To: "आचार्य पवन कुमार शर्मा Prof. Pawan K. Sharma" <talk2pawan@gmail.com>
Cc: bonnie_kahlon@yahoo.com, ckjaggi@gmail.com, sukhdeepsingh.cse@dcrustm.org, amitach1@yahoo.com, Amita Chandra <achandra@physics.du.ac.in>, HoD Maths <hodmaths@cuh.ac.in>, HOD Physics <hodphysics@cuh.ac.in>, HOD Statistics <hodstatistics@cuh.ac.in>, CS and IT <hodcomputerscience@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>, "HoD, Chemistry" <hodchemistry@cuh.ac.in>, ssunita@cuh.ac.in, "Dr. Suneel Kumar" <suneelkumar@cuh.ac.in>, "Dr. Harish Kumar" <harishkumar@cuh.ac.in>, Rajeshgupta@cuh.ac.in, "Dr. Manoj Gupta" <mkgupta@cuh.ac.in>, keshav@cuh.ac.in, Suraj Arya <surajarya@cuh.ac.in>, jitendra@cuh.ac.in, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, arunkajla@cuh.ac.in, "Dr. Rakesh Kumar" <rks@cuh.ac.in>, "Dr. Kapil Kumar" <kapilstats@cuh.ac.in>, kahlon_s@pu.ac.in, "Dr. Vinod Kumar" <vinodkumar@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Devendra Kumar" <devendrastats@cuh.ac.in>, drjitendra@cuh.ac.in

Respected Madam/Sir,
Please find herewith the revised minutes (with minor modification in resolution for agenda no 3a and 3b) of the meeting of the School Board held on 12-09-2022 for your kind consideration and approval.
With Warm Regards

(Revised) Minutes of Meeting of the School Board of School of Basic Sciences held on 12.09.2022

A meeting of the **School Board of School of Basic Sciences**, Central University of Haryana, Mahendergarh was held on **12.09.2022** at **10:30 A.M.** onwards via offline and online (https://meet.google.com/rvh-ukja-fwm) mode in the office of the Dean, School of Basic Sciences, Central University of Haryana.

The following members were present in the meeting:

1. **Dr. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Dr. Keshav Singh Rawat** (Member)
   Head, Department of Computer Science and IT
   Central University of Haryana, Mahendergarh
3. **Dr. Jitendra Kumar** (Member)
   Head, Department of Geography
   Central University of Haryana, Mahendergarh
4. **Dr. Rajesh Kumar Gupta** (Member)
   Head, Department of Mathematics
   Central University of Haryana, Mahendergarh
5. **Dr. Suneel Kumar** (Member)
   Head, Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
6. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
7. **Prof. Sunita Shrivastava** (Member)
   Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
8. **Dr. Manoj Kumar Gupta** (Member)

Department of Chemistry
Central University of Haryana, Mahendergarh

9. **Dr. Suraj Arya** (Member)
Department of CS & IT
Central University of Haryana, Mahendergarh

10. **Dr. Manish Kumar** (Member)
Department of Geography
Central University of Haryana, Mahendergarh

11. **Dr. Arun Kajla** (Member)
Department of Mathematics
Central University of Haryana, Mahendergarh

12. **Prof. Pawan Kumar Sharma** (External Subject Expert)
Professor, Department of Chemistry
Kurukshetra University, Kurukshetra, Haryana

13. **Prof. Chandra K. Jaggi** (External Subject Expert)
Professor, Department of Operational Research
Faculty of Mathematical Sciences, DU, Delhi

14. **Prof. Sukhdeep Singh** (External Subject Expert)
Professor, Department of Computer Science & Engg.
DCRUST, Murthal, Sonipat

15. **Prof. Amita Chandra** (External Subject Expert)
Professor, Department of Physics & Astrophysics Joined online
North Campus, DU, Delhi

16. **Prof. Simrit Kahlon** (External Subject Expert)
Professor, Department of Geography
Panjab University, Chandigarh

17. **Prof. Anil Kumar Yadav** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

18. **Dr. Jitendra Kumar** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

19. **Dr. Devendra Kumar** (Special Invitee)
TIC, Department of Statistics
Central University of Haryana, Mahendergarh

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

Item No	**Description and Recommendation**	**Annexure**
1	Confirmation of the minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022.	
	The minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022 were confirmed.	**Annexure-1-SOBS**
2	To consider and approve the minutes of the meeting of the Board of	

	Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022, be approved.	**Annexure-A**
2a	To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-CH**
2b	To consider and approve the Scheme for first three years and Syllabi for second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in the BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc. programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020. **It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.** **Resolved that the Scheme for first three years (with minor modifications in first and second year) and Syllabi for the second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-II-CH**
2c	To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of	

	Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme and syllabi of the Integrated B.Sc.-M.Sc. programme have been designed. **Resolved that the Scheme and Syllabi for the first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-III-CH**
3.	To consider and approve the minutes of the meetings of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022, be approved.	**Annexure-B**
3a	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and suggested the improvement in the course title of Programming for Data Science as "Programming for Data Science using python" in the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023). **Further, the board suggested that the Department of Computer Science and Department of Statistics should sit together and should try to come up with a Collaborative model for the M.Sc. Data Science programme. In view of that the board resolved that the first semester Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, with minor changes as mentioned above be approved and recommended the same to the Academic Council for consideration and approval.**	**Annexure-I-CS**
3b	To consider and approve the Scheme and Syllabi of the Diploma in	

	Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and the board noted that the proposed one year Diploma Programme is of UG level and of 40 credits. However, the existing CUH ordinance allows the Diploma at PG level only with 52 credits(+-4). In view of that the board suggested that the Diploma in Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022, may be offered after the amendments in the university ordinance regarding guidelines of credits for the UG degree level diploma with updated syllabi.	**Annexure-II-CS**
4.	To consider and approve the minutes of the meeting of the Board of Studies of the Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022.	
	Resolved that the minutes of the meeting of Board of Studies of Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022, be approved	**Annexure-C**
4a	To consider and approve the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval after the incorporation of suggested corrections given below: **i) The name of the course "Solar Energy and Physics of Voltaic" is to be changed as "Fundamentals of Solar Energy".** **ii) In case of "Dissertation" offered to students in Semester IV, it should be explicitly mentioned that a continuous monitoring is required to be done. For that purpose, a minimum of two presentations are to be presented by students during the semester.** **iii) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of M.Sc. (Physics) 2021-23 batch.**	**Annexure-I-PH**
4b	To consider and approve the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session	

	2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Discussed in detail the Schemes and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme w.e.f. Academic Session 2022-2023 (Annexure-IIB-PH)and for 2021-26 batch (Annexure-IIA-PH). **Resolved that the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session 2022-2023) and for 2021-26 batch as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to implementation of below-mentioned changes:** **i) The number of practical lectures for DSE, mentioned in the schemes of Semester V and Semester VI should be four instead of two.** **ii) In case of "Dissertation" offered to students in Semester X, it should be explicitly mentioned that a continuous monitoring is required. For that purpose, a minimum of two presentations by each student are required during the semester.** **iii) A course related to "Soft Skills" may be added in the list of Ability Enhancement courses that can be offered by Department of Psychology, or Department of Education or Department of English Studies** **iv) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of Integrated B.Sc. M.Sc (Physics) for 2021-26 batch.**	**Annexure-IIA-PH** **Annexure-IIB-PH**
4c	To consider and approve the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to incorporation of below-mentioned changes: **i) The number of DCEC courses for the PhD (Physics) course work should be three. Therefore, it was decided unanimously to remove the course of "Nanotechnology and Ion Beam".**	**Annexure-III-PH**

5.	To consider and approve the minutes of the meeting of Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022	**Annexure-D1, D2, D3**
	Resolved that the minutes of the meeting of the Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022 be approved.	
5a	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-MT**
5b	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2022-27 (1-6 Semesters) as approved in BOS meeting of Department of Mathematics held 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	**Annexure-II-MT**
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics w.e.f Academic Session 2022-23, as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved, and recommended the same to Academic Council for consideration and approval.	
5c	Recommendation on the application dated 07-01-2022 received from Mr. Manish Kumar (Roll no. 191217), Research Scholar, on the recommendation of DRC (**Annexure–III-MT**), Department of Mathematics dated 13-01-2022 and BoS (16-03-2022, **Annexure-D1**).	**Annexure-III-MT**
	The case of Mr. Manish Kumar (Roll no. 191217), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 09-08-2019 and the topic of his research was approved on 19-11-2020 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Manish Kumar (Roll no. 191217), Research Scholar is required to complete a minimum residency period of two years after his topic approval date as per clause no 7.10 and 9f of Ordinance-II(A) 2019 for Ph.D. It is further resolved that the remaining**	

	residency period of 10 months 13 days should be completed in one go by Mr. Manish Kumar as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.	
6.	To consider and approve the minutes of the meeting of the Board of Studies (BOS) of the Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of Department of Statistics, School of Basic Sciences held on 10-05-2022 be approved.	**Annexure-E**
6a	To get approval for changing the instructions/notes in the course for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that changing the instructions/notes in the courses for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022, be approved and recommended the same to the Academic Council for consideration and approval.	**Annexure-E**
6b	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics, held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The agenda item 6b is withdrawn as the similar programme i.e. M.Sc. Data Science has been offered by the Department of Computer Science & Information Technology under the same School. **After detailed discussion, the board suggested that the Department of Statistics and Department of Computer Science & Information Technology may start some collaborative and common programmes in near future as per the availability of the faculty members and resources.**	**Annexure-I-ST**
6c	To consider and approve the Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the revised and updated Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics	**Annexure-II-ST**

	held on 10-05-2022, be approved and recommended the same to Academic Council for consideration and approval.	
7.	To consider and approve the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3).	
	Resolved that the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3) be approved.	**Annexure-F1, F2, F3**
7a	To consider and approve the syllabus of M.Sc. Geoinformatics programme in the Department of Geography.	
	Resolved that Scheme and Syllabi of M.Sc. Geoinformatics, two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Geography held on 24-08-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-Geog**
7b	To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job as recommended by Departmental Research Committee (DRC) held on 20-04-2022 and Board of Studies (BoS) meeting held on 11-05-2022 and to recommend the case for Academic Council.	
	The case of Mr. Sourabh Yadav (Roll no. 200785), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 29-11-2020 and the topic of his research was approved on 26-10-2021 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Sourabh Yadav (Roll no. 200785), Research Scholar is required to complete a minimum period of two years after his topic approval date as per clause no 9e and 9f of Ordinance-II(A) for Ph.D 2020. It is further resolved that the remaining period of 1 year 10 months 27 days should be completed in one go by Mr. Sourabh Yadav as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.**	**Annexure-II-Geog**
8.	Any other item(s) with the permission of the Chair.	
	No item was discussed	

The meeting ended with thanks to the Chair.

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(**NAAC Accredited 'A' Grade**)

Curriculum and Syllabi

of

Integrated B.Sc.-M.Sc. (Physics)

Session: 2021-26

DEPARTMENT OF PHYSICS & ASTROPHYSICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	Approved	Approved	
Approval Date :	08.08.2022	12.09.2022	

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VISION AND MISSION

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through the promotion of innovation, creative endeavors, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for the creation of a knowledge community, by building a strong character and nurturing value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research, and innovation in pure and applied areas of learning.

Vision and Mission of the Department of Physics and Astrophysics

Vision

To establish a platform for the dissemination and creation of knowledge through teaching and research in Physics and Astrophysics at various levels. To help create a scientific society that encourages logical thinking.

Mission

- To offer a state of art Academic Programs in Physics and interdisciplinary areas.
- To create an intellectual property through innovations, quality research publications, and patents
- To create state of art research laboratories that will facilitate the research of the Central University of Haryana as well as other academic institutions.

1. Background

i. NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of the Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programs in alignment with the National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted by the adoption of the "Comprehensive Roadmap for Implementation of NEP-2020" in the 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and an indicative timeline for major academic reforms.

The process of revamping the curriculum started with a series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st-century skills for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In the case of UG programs in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council, and other relevant agencies/sources. The University has also developed a consensus on the adoption of Blended Learning with 40% component of online teaching and 60% face-to-face classes for each program.

The revised curricula of various programs could be devised with concerted efforts of the faculty, Heads of the Departments, and the Deans of Schools of Study. The draft prepared by each department was discussed in a series of discussion sessions conducted at the Department, School, and University levels. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice-Chancellor of the University conducted a series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate and Graduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References, and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each program.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii. About the Subject

Physics is the natural science that studies matter, its motion and behavior through space and time, and the related entities of energy and force. Physics is one of the most fundamental scientific disciplines and its main goal is to understand the behavior of the universe and its characteristics.

Physics uses the scientific method to help uncover the basic principles governing light and matter, and to discover the implications of those laws. It assumes that there are rules by which the universe functions, and that those laws can be at least partially understood by humans. It is also commonly believed that those laws could be used to predict everything about the universe's future if complete information was available about the present state of all light and matter.

With the inclusion of Astronomy, Physics became one of the oldest academic disciplines. Physics intersects with many interdisciplinary areas of research. New ideas in physics often explain the fundamental mechanisms studied by other branches of science and suggest new avenues of research in academic disciplines such as mathematics, etc. Advancement in Physics often leads to new technologies.

iii. About the Programme (Nature, extent, and aims)

Integrated B.Sc.-M.Sc. (Physics) is a five-year regular program. There are ten semesters in this program. The duration of each semester is sixteen weeks. Teaching and learning process of Integrated B.Sc.-M.Sc. (Physics) involves theory and practical classes along with seminar presentations and research project work.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools, and other teaching aids that can be used as and when required. Emphasis will be given to laboratory work and visiting National laboratories to give hands-on experience to students. Students will be encouraged to do semester-long projects in their own institutes as well as in reputed institutes at the National level. The aims of the Programme are as follows:

- Understand the underlying Physics in respective specializations, and, be able to teach and guide successfully
- Introduce advanced ideas and techniques that are applicable in respective fields.
- Provide the students with a broad spectrum of Physics Courses
- Emphasize the role of Physics in other disciplines such as (Chemical Sciences, Mathematical Sciences, Life Sciences, and their applied areas)
- Develop the ability of the students to observe, perform, analyze and report an experiment
- Develop the ability of the students to deal with physical models and formulas mathematically
- Equip the students with different practical, intellectual and transferable skills.

- Strengthen the student's knowledge of physics and its applications in the real world.
- Provide the student with mathematical and computational tools and models to be used in solving professional problems
- Improve the inter-disciplinary skills of the students.
- To develop human resources with a solid foundation in theoretical and experimental aspects of respective specializations as a preparation for a career in academia and industry.

iv. Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a degree/diploma/certificate based on the credits acquired. The students will have an option to choose different paths seeking a sphere of knowledge and domain of professional work that can fulfill their dreams. The students will be able to demonstrate their knowledge in advanced branches of Physics. This will establish a platform over which students can pursue higher studies. The possible career paths are:

- Teaching Assignments
- Scientific Assignments
- Instruments development
- Research and Development in Industries
- Simulation Techniques Development in Science
- Role in Renewable Energy Resources
- University/Institute Administrative Assignments
- Technician in Lasers, Accelerators, Detectors, and Electronics
- Astronomer
- Medical Device Designer
- Radiologist

2. Programme Outcomes (POs)

Students enrolled in the Integrated B.Sc.-M.Sc. (Physics) offered by the Department of Physics and Astrophysics under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attaining important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the program.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the program.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate, and analyze scientific problems and innovatively designing and creating products and solutions to real-life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution to burning research problems in the concerned and associated fields at the global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for the betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate to social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish an independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The students shall be able to realize the following specific outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	Identify, formulate, and solve Physics problems
PSO-2	Design and conduct experiments, as well as analyze and interpret data
PSO-3	Apply knowledge of Physics in a different stream of science and to communicate effectively.
PSO-4	Ability to use the techniques, skills, and modern physical tools in a real-world application.
PSO-5	Engage in life-long learning and will have recognition.

4. Graduate Attributes

Some of the characteristic attributes of a graduate in Physics are:

- **Disciplinary knowledge and skills: Capable of demonstrating**
    a. good knowledge and understanding of major concepts, theoretical principles and experimental findings in Physics and its different subfields like Astrophysics and Cosmology, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and other related fields of study, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology, etc.
    b. ability to use modern instrumentation and laboratory techniques to design and perform experiments is highly desirable in almost all the fields of Physics listed above in (a).
- **Skilled communicator:** Ability to transmit complex technical information relating to all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem-solving skills in all the basic areas of Physics.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics, and planning, executing, and reporting the results of a theoretical or experimental investigation.
- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop, and in industry and field-based situations.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.
- **Digitally Efficient:** Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data, and employing modern e-library search tools like Inflibnet, various websites of the renowned Physics labs in countries like the USA, Europe, Japan, etc. to locate, retrieve, and evaluate Physics information.

- **Ethical awareness/reasoning:** The graduate should be capable of demonstrating the ability to think and analyze rationally with a modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.
- **National and international perspective:** The graduates should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing toward the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

5. Structure of Integrated B.Sc.-M.Sc. Course

Semester	Core Courses (CC) each with 06 credits (All courses are compulsory)	Generic Elective (GE) each with 06 credits (to be opted from given list of courses)	Skill Enhancement Course (SEC) each with 02 credits (to be opted from given list of courses)	Discipline Specific Elective (DSE) each with 06/04 credits (to be opted from given list of courses)	Ability Enhancement Compulsory Courses (AECC) (to be opted from given list of courses)	Total Credits
I	CC-01 CC-02	GE-01			AECC-01	22
II	CC-03 CC-04	GE-02			AECC-02	22
III	CC-05 CC-06 CC-07	GE-03	SEC-01			26
IV	CC-08 CC-09 CC-10	GE-04	SEC-02			26
V	CC-11 CC-12		SEC-03	DSE-01 DSE-02		26
VI	CC-13 CC-14		SEC-04	DSE-03 DSE-04		26
VII	CC-15* CC-16* CC-17* CC-18	GE-05*		DSE-05*		26
VIII	CC-19* CC-20* CC-21* CC-22			DSE-06* DSE-07*		26
IX	CC-23* CC-24* CC-25 CC-26			DSE-08* DSE-09*		28
X	CC-27**					20
TOTAL CREDITS						**248**

***4 credits** ****20 credits**

Total Credits of the Course: 248

Types of Courses	Nature	Total Credits	%
Compulsory Courses	Core Courses (CC)	160	64.5%
	Ability Enhancement Compulsory Courses (AECC)	08	3.2%
Elective Courses	Discipline Specific Elective Courses (DSE)	44	17.8%
	Generic Elective Courses (GE)	28	11.3%
	Skill Enhancement Courses Elective Courses (SEC)	08	3.2%

Exit Options: As per appropriate ordinance

6. Learning Outcome Index

Core Course for B.Sc (Hons.)

S. No.		CC-I	CC-II	CC-III	CC-IV	CC-V	CC-VI	CC-VII	CC-VIII	CC-IX	CC-X	CC-XI	CC-XII	CC-XIII	CC-XIV
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basic Physics concepts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with related disciplines	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related field of specialization	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to use in Physics problem	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X	X	_	_	X	_	_	X	X	X	X
8	Skills in performing analysis and interpretation of data	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Develop investigative Skills	X	X	X	X	X	X	X	X	_	X	X	X	X	X
10	Skills in problem solving in Physics and related discipline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop Technical Communication skills	X	X	X	X	-	-	X	X	X	X	X	X	X	X
12	Developing analytical skills and popular communication	X	X	X	X	-	-	-	-	X	_	_	X	X	X
13	Developing ICT skills	X	X	X	X	X	X	X	X	_	X	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	X	X	X	X	X	X	X	X	X	X	X	X	X	X

7. Semester-wise Courses & Credit Distribution

Note: This scheme supersedes the earlier available schemes before this date.

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
(CHOICE BASED CREDIT SYSTEM)

……………………………………………………………………………………..........

Semester I

Total credits: 22

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics-I	SBS PHY 03 101 CC 4004	4	0	0	4
2	Mechanics	SBS PHY 03 102 CC 4004	4	0	0	4
3	Ability Enhancement Compulsory Course (AECC-01)		4	0	0	4
4	Generic Elective Course (GE-01)		4/5	0/1	4/0	6
5	Mathematical Physics-1 Laboratory	SBS PHY 03 103 CC 0042	0	0	4	2
6	Mechanics Laboratory	SBS PHY 03 104 CC 0042	0	0	4	2

Note:

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The AECC course of "Environmental Studies [SBS EVS 0107 AECC 4004]" will be offered in one of the first two semesters as a compulsory course and the student will opt for a course based on Modern Indian Language (MIL) communications in the other semester:
    - English Communications [SBS ENG 0207 AECC 4004]
    - प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1) [SBS SKT 0209 AECC 4004]
    - हिंदी भाषा: रचना एवं व्यवहार [SBS HIN 0208 AECC 4004]

Semester II

Total credits: 22

S. No.	Course Title	Course Code	L	T	P	Credits
1	Electricity and Magnetism	SBS PHY 03 201 CC 4004	4	0	0	4
2	Waves and Optics	SBS PHY 03 202 CC 4004	4	0	0	4
3	Ability Enhancement Compulsory Course (AECC-02)		4	0	0	4
4	Generic Elective Course (GE-02)		4/5	0/1	4/0	6
5	Electricity and Magnetism Lab.	SBS PHY 03 203 CC 0042	0	0	4	2
6	Waves and Optics Lab.	SBS PHY 03 204 CC 0042	0	0	4	2

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

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    - English Communications [SBS ENG 0207 AECC 4004]
    - प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1) [SBS SKT 0209 AECC 4004]
    - हिंदी भाषा: रचना एवं व्यवहार [SBS HIN 0208 AECC 4004]

Semester III

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics–II	SBS PHY 03 301 CC 4004	4	0	0	4
2	Thermal Physics	SBS PHY 03 302 CC 4004	4	0	0	4
3	Analog Systems and Applications	SBS PHY 03 303 CC 4004	4	0	0	4
4	Physics Laboratory-III	SBS PHY 03 304 CC 0084	0	0	8	4
5	Introduction to Computer Programming	SBS PHY 03 305 CC 0042	0	0	4	2
6	Skill Enhancement Course (SEC-01)		2/0	0	0/4	2
7	Generic Elective Course (GE-03)		4/5	0/1	4/0	6

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
  1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

SEC-01
1. Physics Workshop Skills [SBS PHY 03 301 SE 0042]
2. Applied Optics [SBS PHY 03 302 SE 0042]

Semester IV

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics-III	SBS PHY 03 401 CC 4004	4	0	0	4
2	Elements of Modern Physics	SBS PHY 03 402 CC 4004	4	0	0	4
3	Digital Systems and Applications	SBS PHY 03 403 CC 4004	4	0	0	4
4	Physics Laboratory-IV	SBS PHY 03 404 CC 00126	0	0	12	6
5	Skill Enhancement Course (SEC-02)		2/0	0	0/4	2
6	Generic Elective Course (GE-04)		4/5	0/1	4/0	6

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

SEC-02
1. Computational Physics Skills [SBS PHY 03 401 SE 0042]
2. Renewable Energy and Energy Harvesting [SBS PHY 03 402 SE 2002]

Semester V

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Quantum Mechanics and Applications	SBS PHY 03 501 CC 4004	4	0	0	4
2	Solid State Physics	SBS PHY 03 502 CC 4004	4	0	0	4
3	Physics Laboratory-V	SBS PHY 03 503 CC 0084	0	0	8	4
4	Discipline Specific Elective Course (DSE-01)		4/5	0/1	4/0	6
5	Discipline Specific Elective Course (DSE-02)		4/5	0/1	4/0	6
6	Skill Enhancement Elective Course (SEC-03)		2/0	0	0/4	2

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-01
1. Experimental Techniques [SBS PHY 03 501 DS 5106]
2. Biophysics [SBS PHY 03 502 DS 5106]
3. Earth Sciences [SBS PHY 03 503 DS 5106]

DSE-02
1. Nuclear and Particle Physics [SBS PHY 03 504 DS 5106]
2. Atmospheric Physics [SBS PHY 03 505DS 5106]
3. Physics of Devices and Instrumentation [SBS PHY 03 506 DS 5106]

SEC-03
1. Basic Instrumentation Skills [SBS PHY 03 501 SE 0042]
2. Weather Forecasting [SBS PHY 03 502 SE 2002]

Semester VI

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Electromagnetic Theory	SBS PHY 03 601 CC 4046	4	0	0	4
2	Statistical Mechanics-I	SBS PHY 03 602 CC 4046	4	0	0	4
3	Physics Laboratory-VI	SBS PHY 03 603 CC 0084	0	0	8	4
4	Discipline Specific Elective Course (DSE-03)		4/5	0/1	4/0	6
5	Discipline Specific Elective Course (DSE-04)		4/5	0/1	4/0	6
6	Skill Enhancement Elective Course (SEC-04)		2/0	0	0/4	2

The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-03
1. Nanomaterials and Applications [SBS PHY 03 601 DS 5106]
2. Medical Physics [SBS PHY 03 602 DS 5106]

DSE-04
1. Astronomy and Astrophysics [SBS PHY 03 603 DS 5106]
2. Embedded systems- Introduction to Microcontroller [SBS PHY 03 604 DS 5106]

SEC-04
1. Electrical Circuit and Network Skills [SBS PHY 03 601 SE 2002]
2. Radiation Safety [SBS PHY 03 602 SE 2002]
3. Physics for Fun [SBS PHY 03 603 SE 0042]

Semester VII

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Classical Mechanics	SBS PHY 03 701 CC 4004	4	0	0	4
2	Advanced Mathematical Physics	SBS PHY 03 702 CC 4004	4	0	0	4
3	Advanced Quantum Mechanics	SBS PHY 03 703 CC 4004	4	0	0	4
4	Physics Laboratory-VII	SBS PHY 03 704 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-05)		4	0	0	4
6	Generic Elective Course (GE-05)		4	0	0	4

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-05

1. Statistical Mechanics-II [SBS PHY 03 701 DS 4004]
2. Introduction to Hydrogen Energy Systems [SBS PHY 03 702 DS 4004]
3. Astrophysics of Stars [SBS PHY 03 703 DS 4004]

Semester VIII

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Classical Electrodynamics	SBS PHY 03 801 CC 4004	4	0	0	4
2	Atomic and Molecular Physics	SBS PHY 03 802 CC 4004	4	0	0	4
3	Nuclear Physics	SBS PHY 03 803 CC 4004	4	0	0	4
4	Physics Laboratory-VIII	SBS PHY 03 804 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-06)		4	0	0	4
6	Discipline Specific Elective Course (DSE-07)		4	0	0	4

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-06
1. Digital Electronics and Microprocessor [SBS PHY 03 801 DS 4004]
2. Solar Energy and Physics of Photovoltaic [SBS PHY 03 802 DS 4004]

DSE-07
1. General Theory of Relativity [SBS PHY 03 803 DS 4004]
2. Accelerator Physics [SBS PHY 03 804 DS 4004]
3. Characterization Techniques for Materials [SBS PHY 03 805 DS 4004]

Semester IX

Total credits: 28

S. No.	Course Title	Course Code	L	T	P	Credits
1	Condensed Matter Physics	SBS PHY 03 901 CC 4004	4	0	0	4
2	Particle Physics	SBS PHY 03 902 CC 4004	4	0	0	4
3	Physics Laboratory-IX	SBS PHY 03 903 CC 00126	0	0	12	6
4	Minor Project	SBS PHY 03 904 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-08)		4	0	0	4
6	Discipline Specific Elective Course (DSE-09)		4	0	0	4

The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-8
1. Cosmology [SBS PHY 03 901 DS 4004]
2. Plasma Physics [SBS PHY 03 902 DS 4004]

DSE-9
1. Experimental Techniques in Nuclear and Particle Physics [SBS PHY 03 903 DS 4004]
2. Reactor Physics [SBS PHY 03 904 DS 4004]
3. Advanced Carbon Materials [SBS PHY 03 905 DS 4004]

Semester X

Total credits: 20

S. No.	Course Title	Course Code	L	T	P	Credits
1	Dissertation	SBS PHY 03 X01 CC XXX20	-	-	-	20

Note: A continuous monitoring of the work being done will be done by the departmental committee and a minimum of two presentations are to be presented by the student.

Course Contents

(for Semester I to VI)

Core Courses

Mathematical Physics-I

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 101 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basic knowledge of 10+2 standard mathematics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to teach the Calculus, Vector Calculus, Orthogonal Curvilinear Coordinates, Dirac Delta function and its properties and Introductory theory of probability.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The objective of the course is to provide the students training in Calculus to solve various mathematical problems. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
Revise the knowledge of calculus, vectors, vector calculus, probability and probability distributions. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
Learn the Dirac delta function its properties, which have applications in various branches of Physics, especially quantum mechanics.
In the laboratory course, learn the fundamentals of the C and C++ programming languages and their applications in solving simple physical problems involving interpolations, differentiations, integrations, differential equations as well as finding the roots of equations.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Calculus:** Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions, Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.	20
2	**Vector Calculus:** Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).	20
3	**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	8
4	**Introduction to probability:** Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson,	12

	with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **Dirac Delta function and its properties:** Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.	

TEXT BOOKS

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Mathematical Physics, Goswami, 1 st edition, Cengage Learning
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.
- Mathematical Physics, H.K. Dass and R. Verma, 2021, S. Chand & Company.

Mechanics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 102 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Knowledge of Vector Algebra & Vector Calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce elementary concepts of Mechanics to the students so that they are able to understand fundamental aspects of forces, nature of forces and their applications. Objective here is that with the comparatively advanced mathematics tools than their high school curriculum, they will be able to apply these concepts in other branches of Physics and Science in general.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of Physics
● To get familiar with various concepts of mechanical problems related to Gravitational Force, spring force and oscillations.
● To inform the students about applications of mechanics in other science branches.
● To have a clear understanding about concepts related to space, time and relative motion.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the fundamentals of dynamics in constant as well as variable mass systems
● Learn about various concepts related to rotational dynamics and elasticity.
● Learn about gravitational force and spring force
● Understand the basic inception of space and time, and relative motion in inertial as well as non-inertial frames.</td></tr>
<tr><td colspan="8"></td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Fundamentals of Dynamics :** Review of vector algebra and differential calculus of vectors: gradient, divergence and curl. Reference frames. Inertial frames; Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as the gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of Conservation of Energy with an example of a spring-mass system.	18
2	**Rotational Dynamics**: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. **Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.	14
3	**Gravitation and Central Force Motion:** Kepler's Laws. Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts. Motion of a particle under a central	14

	force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. **Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.	
4	**Special Theory of Relativity:** Galilean transformations; Galilean invariance. Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. **Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.	14

TEXT BOOKS

• Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

• Fundamentals-of-Physics-I-Mechanics, R. Shankar, 2014, Yale University Press

•An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

• Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

• Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.

• Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education

• Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

• Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

• University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

• Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning

• Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Mathematical Physics-I Lab.

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mathematical Physics-I Lab.</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 103 CC 0044</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

#	List of Experiments	Hours
1	(see table below)	30

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)

<table>
<tr>
<td>2</td>
<td>
<table>
<tr><td>Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods</td><td>Solution of linear and quadratic equation, solving $\alpha = \tan\alpha ; I = I_0 \left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics</td></tr>
<tr><td>Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation</td><td>Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.</td></tr>
<tr><td>Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method</td><td>Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area
B-H Hysteresis loop</td></tr>
<tr><td>Solution of Ordinary Differential Equations (ODE)
First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods</td><td>First order differential equation
• Radioactive decay
• Current in RC, LC circuits with DC source
• Newton's law of cooling
• Classical equations of motion
Attempt following problems using RK 4 order method:
• Solve the coupled differential equations
$\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dx} = -x$
for four initial conditions
x(0) = 0, y(0) = -1, -2, -3, -4.
Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$
The differential equation describing the motion of a pendulum is $\frac{d^2\vartheta}{dt^2} = -sin(\vartheta)$. The pendulum is release from rest at an angular displacement α, i.e. $\vartheta(0) = \alpha$ $\vartheta'(0) = 0$. Solve the equation for α = 0.1, 0.5 and 1.0 plot ϑ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small $\vartheta(sin(\vartheta)) =$</td></tr>
</table>
</td>
<td>30</td>
</tr>
</table>

TEXT BOOKS

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw‐Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Ed., 2007, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Mechanics Lab.

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Mechanics Lab.</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 104 CC 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
8. To determine Young's Modulus of a Wire by Optical Lever Method.
9. To determine Modulus of Rigidity of a Wire by Maxwell’s needle.
10. To determine the elastic Constants of a wire by Searle’s method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater’s Pendulum.</td><td>60</td></tr>
<tr><td colspan="8">TEXT BOOKS
● Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
● Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
● Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.</td></tr>
</table>

Electricity and Magnetism

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Electricity and Magnetism</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 201 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Knowledge of Vector Algebra & Vector Calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Electricity and Magnetism which covers the topics of Electric Field and Electric Potential, Electrostatic energy of system of charges, Dielectric Properties of Matter, Magnetic Field, Magnetic Properties of Matter, Electromagnetic Induction, Electrical Circuits, Network Theorems and Ballistic Galvanometer</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course will help in understanding basic concepts of electricity and magnetism and their applications.
● Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, the student should be able to
● Demonstrate Coulomb’s law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
● Explain and differentiate the vector (electric fields, Coulomb’s law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
● Apply Gauss’s law of electrostatics to solve a variety of problems.
● Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Electric charges and Coulomb's law:** Electric charge, types and properties of electric charge, Coulomb's law and its applications: electric field due to a uniformly charged infinite wire, circular ring (at a point on its axis), circular disc (at a point on its axis), infinite long plane sheet; electric lines of force, electric moments of a charge, electric dipole and electric field due to an electric dipole. **Gauss's law & its applications:** Electric flux, solid angle: solid angle subtended by a sphere at a point (i) inside it and (ii) outside it, solid angle subtended by a closed surface at a point inside it, Gauss's law and its applications: electric field due to a uniformly charged infinite wire, infinite non-conducting sheet, spherical shell, solid sphere; Coulomb's law from Gauss's law, Force and torque on an electric dipole in an electric field.	15
2	**Electrostatic potential:** Conservative nature of electrostatic field, electric potential difference, electric potential, potential due to a point charge and a set of charges, potential as line integral of field, field as gradient of a scalar function, electric potential due to a uniformly charged wire, circular ring (at a point on its axis), circular disc (at a point on its axis), spherical shell, solid sphere, electric dipole, Uniqueness theorem, Laplace's equation, Poisson's equation, Electrostatic potential due to an arbitrary charge distribution and multipole moments, electrostatic potential energy of a charge in electric field, potential energy of a system of charges, potential energy of a charged sphere, equipotential surfaces, method of images and its application to a point charge near an earthed conducting (i) plane sheet and (ii) a sphere. **Electrostatic Fields in Dielectrics:** Dielectrics, polar and non-polar dielectrics, response of dielectric materials in external electric field, electric field due to polarization, polarization vector, dielectric constant, capacity of a parallel plate capacitor filled with dielectric, dielectric strength, electric susceptibility, free and bound charges, relation between (i) polarization vector and polarization charge densities, (ii) dielectric constant and electric susceptibility, atomic polarizability, Gauss's law for dielectrics, energy stored in a capacitor.	15
3	**Magnetic Field:** Force on a current-carrying wire in a magnetic induction field, torque on a current loop in a uniform magnetic field, current loop as magnetic dipole, Biot-Savart's law and its applications:	15

	magnetic field due to current-carrying straight wire, circular loop (at a point on its axis), solenoid; magnetic lines of force, force on parallel current carrying wire, magnetic flux, Ampere's circuital law and its application to solenoid and a toroid, curl and divergence of magnetic field, magnetic vector potential, divergence of vector potential, Hall effect. **Magnetic Fields in Matter:** Magnetization vector (**M**). Magnetic intensity **(H),** magnetic susceptibility and permeability, relation between **B, H** and **M**, properties paramagnetic, diamagnetic and ferromagnetic materials, B-H curve and hysteresis.	
4	**Electromagnetic Induction:** Introduction, Faraday's laws of electromagnetic induction, Lenz's law, self-inductance and mutual inductance, reciprocity theorem, energy stored in an inductor, Ampere's law for varying currents: need for its modification, modification of Ampere's law, displacement current and Maxwell's equations, series LCR Circuit and parallel LCR Circuit: resonance, power dissipation, quality factor and band width; maximum power transfer theorem. **Electrical Circuits:** AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: Resonance, Power Dissipation, Quality Factor, and Band Width. Parallel LCR Circuit. **Network Theorems:** Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.	15

TEXT BOOKS

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 2017, McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 2012, Pearson Prentice Hall.
4. Feynman Lectures Vol. II, R.P.Feynman, R.B.Leighton, M. Sands, 2012, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2015, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Waves and Optics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Waves and Optics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 202 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to introduce the student to a broad range of physical phenomena involving waves (including mechanical waves, sound waves, and electromagnetic waves), coherence, interference and diffraction phenomena</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn the basics of wave motion.
● Know about the behavior of light due to its wave nature.
● Identify and understand different phenomena due to the interaction of light with light and matter.
● Analyze some of the fundamental laws and principles of light which is used in many important optical instruments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Enable the students to analyze different phenomena due to the interaction of light with light and matter.
● Train the students to use different optical instruments.
● Help the students to understand various natural phenomena using different apparatus in the laboratory.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**SHM:** Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **Superposition of Harmonic Oscillations:** (a) Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. (b) Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.	15
2	**Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves **Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **Superposition of Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. (b) Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. (c) Superposition of N Harmonic Waves. Phase and Group Velocities.	15
3	**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);	15

	Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	
4	**Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. **Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	15

TEXT BOOKS

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
- A textbook of Optics; N Subramanyam, B. Lal and M.N.Avadhanulu; S.Chand Publishing.

Electricity and Magnetism Lab.

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Electricity and Magnetism Lab.</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 203 CC 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth.
4. To study the response curve of a parallel LCR circuit and determine its (a) anti-resonant frequency and (b) Quality factor Q.
5. Conversion of galvanometer to voltmeter and ammeter.
6. To determine the frequency of AC mains using a sonometer.
7. To determine an unknown Low Resistance using a Potentiometer.
8. To determine an unknown Low Resistance using Carey Foster's Bridge.
9. To compare capacitances using De'Sauty's bridge.
10. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
11. To verify the Thevenin and Norton theorems.</td><td>60</td></tr>
</table>

	12. To verify the Superposition and Maximum power transfer theorems. 13. To determine the self-inductance of a coil by Anderson's bridge. 14. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer 15. Determine a high resistance by leakage method using Ballistic Galvanometer. 16. To determine the self-inductance of a coil by Rayleigh's method. 17. To determine the mutual inductance of two coils by the Absolute method.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Waves and Optics Lab.

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Waves and Optics Lab.</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 204 CC 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
</table>

#	List of Experiments	Hours
1	1. To investigate the motion of coupled oscillators 2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law. 3. To study Lissajous Figures 4. Familiarization with Schuster`s focussing; determination of angle of prism. 5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method). 6. To determine the Refractive Index of the Material of a Prism using Sodium Light. 7. To determine Dispersive Power of the Material of a Prism using Mercury Light 8. To determine the value of Cauchy Constants. 9. To determine the Resolving Power of a Prism. 10. To determine wavelength of sodium light using Fresnel Biprism. 11. To determine wavelength of sodium light using Newton's Rings. 12. To determine the wavelength of Laser light using Diffraction of Single Slit.	60

	13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating 14. To determine the Resolving Power of a Plane Diffraction Grating. 15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Mathematical Physics–II

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Mathematical Physics–II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 301 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
10+2 level Mathematics and course of Mathematical Physics-I in Semester I</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Fourier Series, Special Functions, Special Integrals, Theory of Errors, and Partial Differential Equations and its applications in Physics to the students.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Training in mathematical tools like calculus, integration, series solution approach, special function will prepare the student to solve ODE, PDE's which model physical phenomena.
● The student shall develop an understanding of how to model a given physical phenomena such as pendulum motion, rocket motion, stretched string, etc., into set of ODE's, PDE's and solve them.
● These skills will help in understanding the behavior of the modeled system/s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
● Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
● Learn the beta, gamma and the error functions and their applications in doing integrations.
● Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics.
● Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Fourier Series** : Periodic functions. Orthogonality of sine and cosine functions, DirichletConditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	15
2	**Frobenius Method and Special Functions** : Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality	20
3	**Some Special Integrals**: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **Theory of Errors**: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line	10
4	**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.	15

TEXT BOOKS

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Thermal Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Thermal Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 302 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: High School Mathematics & Fundamental Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand the relations between the macroscopic properties of physical systems in equilibrium. The course evaluates the concepts of thermodynamics learnt at school in more advanced perception and develops them further.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamental laws of thermodynamics and their applications to various systems and processes
● To understand the concepts of entropy, thermodynamic potentials and Maxwell's thermodynamic relations
● To give exposure about the kinetic theory of gases, transport phenomena involved in ideal gases, phase transitions and behavior of real gases
● To able the students for solve the problems related to thermodynamics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Grasp the basic concepts and fundamental laws of thermodynamics.
● Understand the concepts of entropy, reversible and irreversible processes, thermodynamic potentials and Maxwell's relations and their physical interpretations.
● Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equipartition theorem, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
● Understand the concept and behavior of ideal and real gases.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes. **Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	18
2	**Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Third Law of Thermodynamics. Unattainability of Absolute Zero. **Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations. Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of Cp-Cv	18
3	**Distribution of Velocities:** Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and	12

	Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.	
4	**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapor and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.	12

TEXT BOOKS

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
- Thermal Physics, B.K. Agrawal, Lok Bharti Publications.

Analog Systems and Applications

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Analog Systems and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 303 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is aimed at understanding of PN Junctions, BJT, MOSFETs, Op-Amps as well as their applications in the Analog domain.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To know about the basics of semiconductor PN junction, its various types and its applications to various electronic circuits.
● To understand the properties, working and applications of bipolar junction transistor as amplifier and oscillators.
● To Familiarize with operational amplifiers, its applications and analysis
● To develop knowledge about analog to digital and digital to analog conversion techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn the foundation knowledge of analog electronic systems.
● Learn the working and applications of PN junction and bipolar junction transistors (BJT).
● Learn to analyze circuits containing PN junction and BJT along with the application of BJT as amplifiers and oscillators.
● Develop basic knowledge of operational amplifier and its applications.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.	15
2	**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains.	15
3	Classification of Class A, B & C Amplifiers. **Coupled Amplifier:** RC-coupled amplifier and its frequency response. **Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	15
4	**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.	15

	Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)	

TEXT BOOKS

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning.
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

Physics Laboratory-III

Scheme Version: 2021-26	**Name of the subject:** Physics Laboratory-III	**L**	**T**	**P**	**C**	**Semester:** III	**Contact Hours per Week:** 8
		0	0	8	4		**Total Hours:** 120
Subject Code: SBS PHY 03 304 CC 0084	**Applicable to Program:** **Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours (Practical)		
			TEE	70 Marks	**Prerequisite of Course:** None		

#	List of Experiments	Hours
1	• To study V-I characteristics of PN junction diode, and Light emitting diode. • To study the V-I characteristics of a Zener diode and its use as voltage regulator. • Study of V-I & power curves of solar cells, and find maximum power point & efficiency. • To study the characteristics of a Bipolar Junction Transistor in CE configuration. • To study the various biasing configurations of BJT for normal class A operation. • To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. • To study the frequency response of voltage gain of a RC-coupled transistor amplifier. • To design Wien bridge oscillator for given frequency using op-amp. • To design a phase shift oscillator of given specifications using BJT. • To study the Colpitt`s oscillator. • To design a digital to analog converter (DAC) of given specifications. • To study the analog to digital convertor (ADC) IC.	60

	● To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain ● To design inverting amplifier using Op-amp (741,351) and study its frequency response ● To design non-inverting amplifier using Op-amp (741,351) & study its frequency response ● To study the zero-crossing detector and comparator ● To add two dc voltages using Op-amp in inverting and non-inverting mode ● To design a precision Differential amplifier of given I/O specification using Op-amp. ● To investigate the use of an op-amp as a Differentiator/Integrator. ● To design a circuit to simulate the solution of a 1st/2nd order differential equation.	
2	● To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method. ● To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus. ● To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method. ● To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and ● Charlton's disc method. ● To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT). ● To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions. ● To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature	60

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Chandra, S. 2005. Computer Applications in Physics. II Edition. New Delhi: Narosa Publication House.

Introduction to Computer Programming

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Introduction to Computer Programming</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 305 CC 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

<table>
<tr><th>#</th><th>List of Experiments</th><th>Hours</th></tr>
<tr><td>1</td><td>Introduction and Overview: Computer Architecture and organization; memory and input/output devices; Number system and computer arithmetic.
Programming with C++: Introduction to the concept of Object Oriented Programming, advantages of C++ over conventional programming languages, tokens, keywords, basic data-types, variable declaration, operators, classes and objects, C++ programming syntax for input/output, control structures: selection structure and loop structure, operators, simple and inline functions, arrays.
Program to perform basic arithmetic operations on two numbers entered by user
Use of decision structures: if, if-else, nested if-else and case statements.
To find the largest number out of two/three numbers
Programs based on use of loop structure: for and while statements.
To find the roots of a quadratic equation.
Programs based on use of 1-D/2-D arrays and to perform basic arithmetic operations.
To find the standard deviation, mean, variance and moments for a set of numbers.</td><td>20</td></tr>
<tr><td>2</td><td>Introduction to mathematical tools: Solution of ordinary differential equations (ODEs): Euler method, modified Euler method, RK methods; Numerical integration of 1D function: Trapezoidal and Simpson's rules.</td><td>20</td></tr>
</table>

	● Program to perform numerical integration of a one-dimensional function using Trapezoidal and Simpson's rules ● Numerical solution of ODEs using Euler's method, modified Euler's method and RK method of 4^{th} order. ● Motion of spherical body falling in (a) viscous medium (b) air ● Projectile motion of a body with horizontal/angular projection. ● Motion of a charged particle in uniform electric/magnetic field, and crossed electric and magnetic field. ● Study of charging and discharging of a capacitor in RC circuit with DC source.	
2	**Random number generation and its applications:** mid square method and multiplicative congruential method; Monte-Carlo simulations. List of exercise (using C++) ● Generation of random numbers using the mid-square method and multiplicative congruential method. ● Monte-Carlo technique to evaluate the value of Pi. ● Monte-Carlo technique to simulate the phenomenon of nuclear radioactivity. **Additional Mathematical Physics problems (using C++) based on:** ● Dirac Delta Function, Fourier Series ● Frobenius methods and Special functions ● Calculation of error for each data point of observations recorded in experiments done earlier ● Calculation of least square fitting manually without giving weightage to error. ● Compute the nth roots of unity for n = 2, 3, and 4. ● Find the two square roots of −5+12j.	20
TEXT BOOKS ● Chandra, S. 2005. Computer Applications in Physics. II Edition. New Delhi: Narosa Publication House. ● Verma R.C., Ahluwalia, P.K., Sharma, K.C. 2000. Computational Physics. I Edition. New Delhi: New Age International Publishers. ● Balagurusamy E. 2015. Object Oriented Programming with C++. VI Edition. New Delhi: McGraw Hill Ed. (India).		

Mathematical Physics-III

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mathematical Physics-III</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 401 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics-I and Mathematical Physics-II</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Complex Analysis, Integrals Transforms, Fourier Transforms, Laplace Transform and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Knowledge of various mathematical tools like complex analysis, integral transform will equip the student with reference to solve a given ODE, PDE.
● These skills will help in understanding the behavior of the modeled system/s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn about the complex numbers and their properties, functions of complex numbers and their properties such as analyticity, poles and residues. The students are expected to learn the residue theorem and its applications in evaluating definite integrals.
● Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Complex Analysis-I: Brief Revision of Complex Numbers and their GraphicalRepresentation. Euler's formula, De Moivre's theorem, Roots</td><td>12</td></tr>
</table>

	of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions.	
2	**Complex Analysis-II:** Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.	12
3	**Integrals Transforms:** Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.	18
4	**Laplace Transforms:** Laplace Transform (LT) of Elementary functions. Properties ofLTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	18

TEXT BOOKS

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3 rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8 th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7 th Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Elements of Modern Physics

<table>
<tr><td rowspan="2">Scheme Version :

2021-26</td><td rowspan="2">Name of the subject:
Elements of Modern Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 402 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="8">This course aims at providing knowledge of One dimensional potential problem of bound states and scattering and elementary introduction of nuclear physics with emphasis on

(i) Nuclear Structure
(ii) Nuclear Forces
(iii) Nuclear Decays
(iv) Fission and Fusion</td></tr>
<tr><td>Course Objectives</td><td colspan="8">● To Comprehend the failure of classical physics and need for quantum physics.
● To Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.
● To Formulate the basic theoretical problems in one, two and three dimensional physics and solve them.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After completion of this course, students would be able to:

● Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
● Understand the theory of quantum measurements, wave packets and uncertainty principle.
● Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and</td></tr>
</table>

	time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier. ● Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Planck's Postulate, and wave and particle like properties of radiation:** Relation of quantum physics to classical physics: Theory of cavity radiation, Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.	15
2	**Heisenberg uncertainty principle and Schrodinger theory:** Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.	15
3	**Solution of Schrodinger equation for one dimensional problems:** One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.	14

	Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.	
4	**Nuclear models:** Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **Radioactivity:** stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. **Fission and fusion:** mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions)	16

TEXT BOOKS

• Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
• Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
• Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
• Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
• Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
• Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
• The Picture Book of Quantum Mechanics, S. Brandt and H. D. Dahmen, 2012, Springer; 4th edn
• Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
• Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
• Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
• Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
• Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill
• Quantum Mechanics, J. L. Powell and B. Crasemann, Dover Publications, 2015.

Digital Systems and Applications

Scheme Version: 2021-26	**Name of the subject:** Digital Systems and Applications	**L**	**T**	**P**	**C**	**Semester: IV**	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours:** 60
Subject Code: SBS PHY 03 403 CC 4004	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	70 Marks	**Prerequisite of Course:** None		

Course Description	This course aims to provide a complete insight into the modern design of digital systems fundamentals from an eminently practical point of view. It will allow students to lay the foundation for the design of complex digital systems.
Course Objectives	● To know about the basic laboratory equipment electronics. ● To understand basic digital electronics concepts and devices. ● To analyze digital circuits.
Course Outcomes	After completion of this course, students would be able to: ● Identify and understand digital electronic principles and systems. ● Apply the knowledge to analyze and apply digital circuits in solving circuit level problems. ● Build real life applications using digital systems.

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **Integrated Circuits:** (a) Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.	18

	Digital Circuits: (a) Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers **Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	
2	**Data processing circuits:** (a) Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop	15
3	**Timers:** (a) IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **Shift registers:** (a) Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **Counters (4 bits):** (a) Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **Computer Organization:** (a) Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map	15
4	**Intel 8085 Microprocessor Architecture:** Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **Introduction to Assembly Language:** 1 byte, 2 byte & 3 byte instructions.	12

TEXT BOOKS

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.

- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1 st edition, McGraw Hill
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Physics Laboratory-IV

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Physics Laboratory-IV</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 404 CC 00126</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>150 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

#	List of Experiments	Hours
1	1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO. 2. To test a Diode and Transistor using a Multimeter. 3. To design a switch (NOT gate) using a transistor. 4. To verify and design AND, OR, NOT and XOR gates using NAND gates. 5. To design a combinational logic system for a specified Truth Table. 6. To convert a Boolean expression into logic circuit and design it using logic gate ICs. 7. To minimize a given logic circuit. 8. Half Adder, Full Adder and 4-bit binary Adder. 9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C. 10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates. 11. To build JK Master-slave flip-flop using Flip-Flop ICs 12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram. 13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs. 14. To design an astable multivibrator of using 555 Timer. 15. To design a monostable multivibrator using 555 Timer. 16. Write the following programs using 8085 Microprocessor a) Addition and subtraction of numbers using direct addressing mode	60

	b) Addition and subtraction of numbers using indirect addressing mode c) Multiplication by repeated addition. d) Division by repeated subtraction. e) Handling of 16-bit Numbers. f) Use of CALL and RETURN Instruction. g) Block data handling. h) Other programs (e.g. Parity Check, using interrupts, etc.).	
2	1. Measurement of Planck's constant using black body radiation and photo-detector 2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light 3. To determine work function of material of filament of directly heated vacuum diode. 4. To determine the Planck's constant using LEDs of at least 4 different colours. 5. To determine the wavelength of H-alpha emission line of Hydrogen atom. 6. To determine the ionization potential of mercury. 7. To determine the absorption lines in the rotational spectrum of Iodine vapour. 8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet. 9. To setup the Millikan oil drop apparatus and determine the charge of an electron. 10. To show the tunneling effect in tunnel diode using I-V characteristics. 11. To determine the wavelength of laser source using diffraction of single slit. 12. To determine the wavelength of laser source using diffraction of double slits. 13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating	60
3	**Introduction to Numerical computation software Scilab:** Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization, User defined functions.	60

	Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays; An introduction to Scilab file processing, file opening and closing, Binary I/O functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program. **Exercises (using Scilab) based on:** ● Curve fitting, Least square fit, Goodness of fit, standard deviation ● Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems. ● Generation of Special functions using and User defined functions in Scilab ● Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods, Second order differential equation, Fixed difference method, Partial differential equations	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- www.scilab.in/textbook_companion/generate_book/291

Quantum Mechanics and Applications

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Quantum Mechanics and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 501 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of time dependent Schrodinger equation, time independent Schrodinger equation. There will be a detailed discussion of bound states in an arbitrary potential. Quantum Theory of hydrogen-like atoms will be developed. The behavior of atoms in Electric and Magnetic Fields is discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• This course shall develop an understanding of how to model a given problem such as particle in a box, hydrogen atom, hydrogen atom in electric fields.
• Many electron atoms, L-S and J-J couplings.
• These skills will help in understanding the different Quantum Systems in atomic and nuclear physics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
• After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
• Through understanding the behavior of quantum particle encountering a i) barrier, ii) potential.
• Student gets exposed to solving non-relativistic hydrogen atom, and multi-electrons systems for their spectrum and eigenfunctions.</td></tr>
</table>

	• Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Time dependent Schrodinger equation:** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **Time independent Schrodinger equation-**Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.	16
2	**General discussion of bound states in an arbitrary potential-** continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite Polynomials; ground state, zero point energy & uncertainty principle.	12
3	**Quantum theory of hydrogen-like atoms:** time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first	18

	excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. **Many electron atoms:** Pauli's Exclusion Principle. Symmetric & Antisymmetric WaveFunctions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and AlkaliAtoms (Na, etc.).	
4	**Atoms in Electric & Magnetic Fields:** Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern- Gerlach Experiment. Zeeman Effect. Orbital angular momentum, General Formalism of Angular Momentum, Addition of Angular Momenta, Spin Angular Momentum: Stern-Gerlach Experiment; Pauli Matrices and Spinors, Clebsch-Gordan Coefficients.	14

TEXT BOOKS

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Principles of Quantum Mechanics, R. Shankar, Springer; 2nd ed., 2014
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Solid State Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Solid State Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 502 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Modern Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory, magnetism, ferroelectricity, and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.
● To understand the fundamentals of dielectric, ferroelectric and magnetism phenomenon in solids
● To make acquainted with several types of electric and magnetic materials and their exciting properties
● To develop the scientific and positive attitudes in students related to the materials science which is a part of solid-state physics
● To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Identify various crystal structures and their symmetries in solids and learn the basic concepts of X-ray diffraction, rotating crystal, and Laue methods.
● Explain the theories and phenomena of lattice dynamics, and thermal properties (specifically specific heat) in solids
● Calculate the specific heat and density of states of various solids and recognize the importance of band theory, effective mass, Hall effect etc. in solids.</td></tr>
</table>

	● Explain the dielectric phenomenon in crystals with their exciting properties and learn the basics of ferroelectric crystals. ● Describe the diamagnetism, paramagnetism, and ferromagnetism phenomenon in solids, CO.6. Illustrate some exciting phenomena such as Meissner effect, Isotope effect, London's equations, and BCS theory of superconductors.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Ewalds' construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.	14
2	**Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T3 law. **Electrons in Solids:** Electrons in metals- Introduction to Drude Model, Density of states (1-D, 2-D, 3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).	20
3	**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	14
4	**Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Para- magnetism. Hunds's rule. Weiss's Theory of Ferromagnetism and Ferromagnetic	12

	Domains. Curie’s law. B-H Curve. soft and hard material and Energy Loss Hysteresis. **Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London’s Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)	

TEXT BOOKS

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Physics Laboratory-V

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Physics Laboratory-V</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
8</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours:
120</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 503 CC 0084</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 1500C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.</td><td>40</td></tr>
</table>

	12. Measurement of change in resistance of a semiconductor with magnetic field.	
2	1. Study of Electron spin resonance- determine magnetic field as a function of the resonance 2. frequency 3. Study of Zeeman effect: with external magnetic field; Hyperfine splitting 4. To show the tunneling effect in tunnel diode using I-V characteristics. 5. Quantum efficiency of CCDs	20
3	1. Determine output characteristics of a LVDT & measure displacement using LVDT 2. Measurement of Strain using Strain Gauge. 3. Measurement of level using capacitive transducer. 4. To study the characteristics of a Thermostat and determine its parameters. 5. Study of distance measurement using ultrasonic transducer. 6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75) 7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD). 8. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope. 9. To design and study the Sample and Hold Circuit.To plot the frequency response of a microphone. 10. To measure Q of a coil and influence of frequency, using a Q-meter.	30
4	**Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like** **1.** Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: $\frac{dy^2}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{\hbar}[V(r) - E]$, and $V(r) =- \frac{e^2}{r}$ Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that	30

	the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $\sqrt{(eV\text{Å})}$, ħc = 1973 (eVÅ) and m = 0.511x106 eV/c^2. **2.** Solve the s-wave radial Schrodinger equation for an atom: $\frac{dy^2}{dr^2} = A(r)u(r),$ where $A(r) = \frac{2m}{\hbar}[V(r) - E]$, where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential $V(r) =- \frac{e^2}{r}e^{(-r/a)}$. Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $\sqrt{(eV\text{Å})}$, m = 0.511×10^{-6} eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases. **3 .** Solve the s-wave radial Schrodinger equation for a particle of mass m: $\frac{dy^2}{dr^2} = A(r)u(r),$ where $A(r) = \frac{2m}{\hbar}[V(r) - E]$, For the anharmonic oscillator potential $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$for the ground state energy (in MeV) of a particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3} In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases. **4.** Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule: $\frac{dy^2}{dr^2} = A(r)u(r),$ where $A(r) = \frac{2\mu}{\hbar}[V(r) - E]$,Where μ is the reduced mass of the two-atom system for the Morse potential $V(r) = D\left[e^{-2\alpha r'} - e^{-\alpha r'}\right],\ r' = \frac{r-r_0}{r}$ Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.Take: m = 940x106 eV/c^2, D = 0.755501 eV, α = 1.44, r_0= 0.131349 Å	
TEXT BOOKS		

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw‐Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Electromagnetic Theory

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Electromagnetic Theory</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 601 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Thermal Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course provides Review of Maxwell's equations and discuss EM wave propagation in unbounded media of various types. The polarization of electromagnetic waves, wave guides, and optical fibres are discussed in detail.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Comprehend the role of Maxwell's equation in unifying electricity and magnetism.
● Derive and understand associated with the properties, EM wave passing through the interface between two media like Reflection, Refraction, Transmission and EM wave
● Learn the application of EM theory to
(i) Wave guides of various types
(ii) Optical fibers in theory and experiment</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
● Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
● Understand the linear, circular and elliptical polarization of em waves. Production as well as detection of waves in the laboratory.
● Learn about optical fibers and waveguides.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Maxwell Equations:** Review of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **EM Wave Propagation in Unbounded Media:** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gasses, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	14
2	**Reflection of a plane EM Wave at a planar boundary:** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, Metallic reflection (normal Incidence) **Reflection of an evanescent EM Wave at planar boundary:** Introduction to evanescent waves. Reflection & Refraction of an EM evanescent wave at plane interface between two dielectric media, Energy propagation in evanescent EM waves.	14
3	**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light.	16

	Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	
4	**Wave Guides:** Planar optical waveguides. Planar dielectric waveguide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **Optical Fibres:-** Numerical Aperture. Step and Graded Indices (Definitions Only).Single and Multiple Mode Fibres	12

TEXT BOOKS

• Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

• Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.

• Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

• Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill

• Classical Electricity and Magnetism, W. Panofsky and M. Phillips, 2012.Dover publications

• Principles of Optics, M. Born and E. Wolf, 1999, Cambridge University Press.

• Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.

• Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.

• Evanescent Waves, F. de Fornel, 2001, Springer-Verlag Berlin Heidelberg

• Understanding energy propagation during reflection of an evanescent electromagnetic wave: Am. J. Phys., 89, 877 (2021)

• Microwave Devices and Circuits, Samuel Y. Liao, Pearson Education India; 3rd edn, 2003

Statistical Mechanics-I

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 602 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Thermal Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course introduces the techniques of statistical mechanics which has broad and rich applications in various fields including quantum mechanics, condensed matter physics, classical mechanics, astrophysics, bio-physics, electrodynamics, etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of statistical mechanics
● To make familiar with various statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.
● To understand the basic aspects of theory of radiation
● To able the students for solve the problems related to statistical mechanics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Understand the concepts of macro and micro states, phase space, thermodynamic probability, partition function etc. and apply the thermodynamic probability and partition function to calculate the thermodynamic variables for ideal gas and finite level system.
● Illustatre the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics
● Apply FD and BE statistics in various model problems (electron in solids, white dwarf blackbody radiation and helium gas).
● Understand the properties and laws related with thermal radiation.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	16
2	**Bose-Einstein Statistics:** B-E Distribution law, Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	20
3	**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly degenerate Fermi Gas, Fermi Energy Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	12
4	**Theory of Radiation:** Properties of Thermal Radiation and Radiation Pressure. Blackbody Radiation and its spectral distribution. Kirchhoff law. Stefan-Boltzmann law and its Thermodynamic proof. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law and Wien's Displacement law from Planck's law.	12

TEXT BOOKS

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2 nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Physics Laboratory-VI

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Physics Laboratory-VI</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
8</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours:
120</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 603 CC 0084</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="5">List of Experiments</td><td colspan="2">Hours</td></tr>
<tr><td>1</td><td colspan="5">1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston’s airfilm.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection
using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for airglass
interface.</td><td colspan="2">90</td></tr>
</table>

<table>
<tr><td></td><td>11. To verify the Stefan`s law of radiation and to determine Stefan’s constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.</td><td></td></tr>
<tr><td>2</td><td>Use C/C++/Scilab/Python and other numerical simulations for solving the problems based on Statistical Mechanics like

1. Plot Planck’s law for Black Body radiation and compare it with Wein’s Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases.
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.</td><td>30</td></tr>
</table>

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. 2007, Wiley India Edition.
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.

DSE PAPERS

Experimental Techniques

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Experimental Techniques</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 8 (4,4)</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 120 (60,60)</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 501 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 (30,15) Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 (70,35) Marks</td><td colspan="3">Prerequisite of Course:
Knowledge of basic electronics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Accuracy and precision, Different types of errors and statistical analysis of data, Noise and signal, signal to noise ratio, different types of noises, Electromagnetic interference and necessity of grounding, Transducer, Different types of transducers and sensors, Digital multimeter and Vacuum systems including ultrahigh vacuum systems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Develop skills to analyse data, make approximation and perform error analysis using basic methods of statistics.
Learn the working principle of transduces, their application and study of the efficiency.
Develop understanding of analog and digital instruments and earn to use them in making physical measurements.
Develop their understanding of signal, noise, and fluctuations in making physical measurements.
Understanding of Impedances Bridges, Q meters as well as vacuum systems using various types of pumps and pressure gauges.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
About accuracy and precision, different types of errors and statistical analysis of data.
About Noise and signal, signal to noise ratio, different types of noises and their identification.</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">

- Concept of electromagnetic interference and necessity of grounding.
- About transducers and basic concepts of instrumentation-Different types of transducers and sensors.
- Working of a digital multimeter.
- Vacuum systems including ultrahigh vacuum systems.
- Conduct Experiments using different transducers including LVDT and gain hands on experience and verify the theory.

</td></tr>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.
Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer functionand frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise.
Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.</td><td>20</td></tr>
<tr><td>2</td><td>Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filleddetector, ionization chamber, scintillation detector.</td><td>20</td></tr>
</table>

3	**Digital Multimeter**: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement **Impedance Bridges and Q-meter**: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.	**20**
4	**Vacuum Systems**: Characteristics of vacuum: Gas law, Mean free path. Application ofvacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).	**15**

TEXT BOOKS

- Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

Biophysics

Scheme Version: 2021-26	Name of the subject: Biophysics	L	T	P	C	Semester: V	Contact Hours per Week: 6
		5	1	0	6		Total Hours: 75
Subject Code: SBS PHY 03 502 DS 5106	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 150)**	**CIE**	45 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	105 Marks	**Prerequisite of Course:**		
Course Description	This course aims at providing knowledge of Molecules of Life, The complexity of Life and Evolution .						
Course Objectives	● Basic concepts about biological physics and evolution are learned.						
Course Outcomes	After completion of this course, students would be able to: ● Acquire mastery of the fundamental principles and applications of various branches of Physics in understanding biological systems. ● Nuggets of thermodynamics and statistical mechanics, electricity and magnetism, will help in understating heat transfer in biomaterials. ● Relevance of chemistry principles and thermodynamics in understanding energy transfer mechanism and protein folding in biological systems. ● He /she will acquire necessary mathematical skills in differential equations, analysis, and linear algebra for simulation studies. ● A basic course in bioPhysics will provide proficiency in basic lab skills, includin understanding and using modern instrumentation and computers. ● Get exposure to complexity of life at i) the level of Cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere						

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Overview:** The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self- replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.	18
2	**Molecules of life:** Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally	18
3	**The complexity of life:** At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development. Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.	21

4	**Evolution:** The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.	18

TEXT BOOKS

- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
- Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)
- Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
- An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
- Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Earth Sciences

Scheme Version: 2021-26	**Name of the subject:** Earth Sciences	**L**	**T**	**P**	**C**	**Semester:** V	**Contact Hours per Week:** 6
		5	1	0	6		**Total Hours:** 75
Subject Code: SBS PHY 03 503 DS 5106	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 150)**	**CIE**	45 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	105 Marks	**Prerequisite of Course:**		
Course Description	This course aims at providing knowledge The Earth and the Universe, Structur, Dynamical Processes, Evolution and Contemporary dilemmas: Disturbing the Earth						
Course Objectives	● Knowledge of the place of Earth in this Universe and its formation, structure and its evolution shall enable the student to appreciate the reasons for keeping Earth 'SAFE'						
Course Outcomes	After completion of this course, students would be able to learn: ● about origin of Universe, place of Earth as a third rock revolving around Sun, its satellite Moon and in general evolution of present day Universe. ● overview of the structure and evolution of the Earth as a dynamic planet within our solar system ● Application of physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure. The origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top layer shall be understood. ● Climate and various roles played by water cycle, carbon cycle, nitrogen cycles in maintain steady state of earth shall be explored. ● This will enable the student to understand the contemporary dilemmas (climate change, biodiversity loss, population growth, etc.) disturbing the Earth						

	● In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, student will be to appreciate need to 'save' Earth.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**The Earth and the Universe:** (a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. (b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. (c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.	18
2	**Structure:** (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior? (b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems. (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds. (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers. (e) The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms	18
3	**Dynamical Processes:** (a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea- floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.	18

	(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis. (c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones. **Climate:** i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system. (d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state	
4	**Evolution:** Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent. 1. Time line of major geological and biological events. 2. Origin of life on Earth. 3. Role of the biosphere in shaping the environment. 4. Future of evolution of the Earth and solar system: Death of the Earth. **Disturbing the Earth – Contemporary dilemmas** (a) Human population growth. (b) Atmosphere: Green house gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.	21

TEXT BOOKS

- Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.
- Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books
- Holme's Principles of Physical Geology. 1992. Chapman & Hall.
- Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Nuclear and Particle Physics

Scheme Version: 2021-26	**Name of the subject:** Nuclear and Particle Physics	**L**	**T**	**P**	**C**	**Semester: V**	**Contact Hours per Week:** 6
		5	1	0	6		**Total Hours:** 75
Subject Code: SBS PHY 03 504 DS 5106	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 150)**	**CIE**	45 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	105 Marks	**Prerequisite of Course:** Elements of Modern Physics and Quantum Mechanics		
Course Description	This course aims at providing knowledge of General properties of nuclei, Nuclear models, Radioactive decays, Nuclear reactions, Interaction of nuclear radiation with matter, Detectors for nuclear interaction, Particle accelerators and Elementary particles and their properties.						
Course Objectives	● Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure. ● To understand, explain and derive the various theoretical formulation of nuclear disintegration like α decay, β decay and decays. ● Develop basic understanding of nuclear reactions and decays with help of theoretical formulate and laboratory experiments. ● Skills to develop basic understanding of the interaction of various nuclear radiation with matter in low and high energy						
Course Outcomes	● Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph. ● Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell						

	model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles. ● Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays, the properties of the constituents of these rays and the mechanisms of the emissions of these rays, outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series. ● Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential. ● Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation. ● Learn about the detectors of nuclear radiations- the Geiger-Mueller counter, the scintillation counter, the photo-multiplier tube, the solid state and semiconductor detectors.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**General Properties of Nuclei**: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic nuclear excites states. moment, electric moments, **Nuclear Models**: Liquid drop model approach, semi empirical mass formula andsignificance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	20
2	**Radioactivity decay**: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b)[] -decay: energy kinematics for []- decay, positron	15

	emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **Nuclear Reactions**: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	
3	**Interaction of Nuclear Radiation with matter:** Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interactionwith matter. **Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	20
4	**Particle Accelerators**: Accelerator facility available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **Particle physics**: Particle interactions; basic features, types of particles and its families.Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quarkmodel, color quantum number and gluons.	20

TEXT BOOKS

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Atmospheric Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Atmospheric Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 505 DS 5106</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of General features of Earth's atmosphere, Atmospheric dynamics, Atmospheric waves, Atmospheric Radar and Lidar and Atmospheric Aerosols.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Develop skills to describe, understand and make measurements of various parameters to describe the physics of earth's atmosphere.
● Learn skills to formulate, solve the theoretical equations describing the atmospheric dynamics and develop software to simulate and demonstrate in laboratory the various atmospheric phenomenon like Atmospheric oscillations of various types and Atmospheric waves of various types.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● Good knowledge of Earth's atmosphere, its composition, effective temperature, Greenhouse effect. Hydrostatic equation and atmospheric thermodynamics. Local winds, clouds, fog, monsoon, cyclones, sea breeze and land breeze and thunderstorms, etc.
● Essential knowledge of the instruments of meteorological observation, meteorological processes and systems.
● Understanding atmospheric dynamics, fundamental forces, conservation laws, rotating coordinate system and equations of motion. Circulation, vorticity, various types of circulations, atmospheric oscillations: biannual, annual and semi-annual oscillations.
● Understanding atmospheric waves. Surface water waves, acoustic waves, buoyancy waves, atmospheric gravity waves (AGW) and its propagation in</td></tr>
</table>

	non-homogeneous medium, Lamb and Rossy waves and their propagation in 3-dimension. Wave absorption and non linear effects. ● Skills to use atmospheric Radar and Lidar to study atmospheric phenomenon, basic knowledge of Radars and Lidars including Radar equation and signal processing. ● Develop numerical skills to do data analysis from Radar and Lidar. ● Knowledge of the classification and properties of aerosols, their concentrations and size distribution. Production and removal of aerosols. Radiative and health effects and observation techniques for aerosols. ● Understanding the absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Boyer-Lambert law, optical phenomenon in atmosphere. Basics of radiometry.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**General features of Earth's atmosphere**: Thermal structure of the Earth'sAtmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms	15
2	**Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservationlaws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. **Atmospheric Waves**: Surface water waves, wave dispersion, acoustic waves,buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and	20

	its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration	
3	**Atmospheric Radar and Lidar**: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.	10
4	**Atmospheric Aerosols**: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.	15

TEXT BOOKS

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press;3 rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S Fukao and KHamazu, Springer Japan, 2014

Physics of Devices and Instrumentation

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Physics of Devices and Instrumentation</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 506 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Metal oxide semiconductors, UJT, JFET, MOSFET, Charge coupled Devices and Tunnel Diode, Power Supply and the role of Capacitance and Inductance filters, Active and passive filters and various types of filters, Multivibrators using transistors, Phase locked loops, voltage controlled oscillator, Photolithography for IC fabrication, about masks and etching, Parallel and serial communications and USB standards and GPIB, Different modulation techniques.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Acquire knowledge and skills to understand the working of the following devices and instruments and practical knowledge to use them by doing experiments in the laboratory.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to Master the following:
● Metal oxide semiconductors, UJT, JFET, MOSFET, Charge coupled Devices and Tunnel Diode.
● Power Supply and the role of Capacitance and Inductance filters.
● Active and passive filters and various types of filters.
● Multivibrators using transistors, Phase locked loops, voltage controlled oscillators
● Basics of photolithography for IC fabrication, about masks and etching.
● Concepts of parallel and serial communication and knowledge of USB standards and GPIB.
● Basic idea of communication including different modulation techniques.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Devices**: Characteristic and small signal equivalent circuits of UJT and JFET. Metal- semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.	18
2	**Power supply and Filters:** Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **Multivibrators:** Astable and Monostable Multivibrators using transistors. **Phase Locked Loop(PLL)**: Basic Principles, Phase detector(XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046)	20
3	**Processing of Devices:** Basic process flow for IC fabrication, Electronic grade silicon.Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation	18
4	**Digital Data Communication Standards**: Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.	19

	Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK	

TEXT BOOKS

- Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3 rd Ed.2008, John Wiley & Sons
- Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
- Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd
- Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Introduction to Measurements & Instrumentation, A.K. Ghosh, 3 rd Ed., 2009, PHI Learning Pvt. Ltd.
- Semiconductor Physics and Devices, D.A. Neamen, 2011, 4 th Edition, McGraw Hill
- PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

Nano Materials and Applications

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Nano Materials and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 601 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course will familiarize the students to the science related to various phenomena observed at the nanoscale. Starting from an introduction to the basic ideas of nanoscience and nanotechnology, various examples will be discussed which highlight the impact of nanoscale on various properties of technological interest. Technologies built on these phenomena will be discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Provide a systematic coverage and insight into the promising area of nano materials in order to facilitate the understanding of the nature and prospects for the field.
● Provide information about various synthesis and characterization techniques of nano materials.
● Discuss optical and electronic transport properties of nano materials.
● Discuss applications of nano materials in various fields.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">This course will enable a student to
CO102C.1. Gather sufficient knowledge about the fascinating behaviour of nanomaterials and tuning of such properties for different applications.
CO102C.2. Obtain information on experimental methodologies with necessary theoretical background, which may be useful for pursuing further study on the areas of nanoscience and technology.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **Synthesis of Nanostructure Materials:** Top down and Bottom up approach, Photolithography. Ball milling. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electrodeposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE	19
2	**Characterization:** X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **Electron Transport:** Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects	18
3	**Optical Properties:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.	18
4	**Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).	18

TEXT BOOKS

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

Medical Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 602 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Physics of the Body, Physics of Diagnostic and Therapeutic Systems, Radiation Physics, Medical Imaging Physics, Radiation Oncology Physics, Radiation and Radiation Protection, and Physics of Diagnostic and Therapeutic Systems</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Essential physics of Medical Imaging, Radiological Physics, Therapeutic Systems and Radiation Therapy is acquired.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">This course will enable the student to:
● Focus on the application of Physics to clinical medicine.
● Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
● Learn about the human body, its anatomy, physiology and bioPhysics, exploring its performance as a physical machine. Other topics include the Physics of the senses.
● He / She will study diagnostic and therapeutic applications like the ECG, radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
● Gain knowledge with reference to working of various diagnostic tools , medical imaging techniques, how ionizing radiation interacts with matter, how it affects living organisms and how it is used as a therapeutic technique and radiation safety practices</td></tr>
</table>

	● Imparts functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Physics of Body-I:** Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics ofbody movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. Energy household of the body: Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. Pressure system of body: Physics of breathing, Physics of cardiovascular system. **Physics of Body-II:** Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. Optical system of the body: Physics of the eye. Electrical system of the body: Physics of the nervous system, Electrical signals and information transfer.	20
2	**Physics of Diagnostic and Therapeutic Systems-I: X-Rays:** Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. X-ray tubes & types: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit. Single and three phase electric supply. Power ratings. Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables. **Radiation Physics:** Radiation units exposure, absorbed dose, units: rad, gray,relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation	20

	Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid State detectors, TFT.	
3	**Medical Imaging Physics**: Evolution of Medical Imaging, X-ray diagnosticsand imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). (9 Lectures) **Radiation Oncology Physics**: External Beam Therapy (Basic Idea):Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy- LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.	20
4	**Radiation and Radiation Protection:** Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose. **Physics of Diagnostic and Therapeutic Systems-II:** Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment.	15

	Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.	

TEXT BOOKS

- Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
- Basic Radiological Physics Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- Physics of the human body, Irving P. Herman, Springer (2007).
- Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3 rd edition (2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
- The Physics of Radiology-H E Johns and Cunningham.

Astronomy and Astrophysics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Astronomy and Astrophysics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week:
6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 604 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Astronomical scalar and concepts of positional astronomy, Astronomical techniques for making measurements, Basics of solar and stellar physics, Milky Way and Galaxies – introductory knowledge and Large scale structures and expending universe.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Skills to learn and operate astronomical instruments to perform observations related to the positional astronomy measurement.
● Conceptualize skills to understand basic parameters for describing the properties of stars and making experimental measurements, their interpretation and role in understanding of astrophysical phenomenon. Study of solar and stellar spectra.
● Learn to describe solar parameters, solar atmosphere, origin of solar system, solar and extra-solar planets, planetary rings.
● Acquire basic knowledge of Milky Way and Galaxies, their properties and structure.
● Skills for understanding basics of large scale structures and expending universe.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● Ability to comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and measurement of distances, time and temperature and radius of star.
● Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram</td></tr>
</table>

	● Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes. ● Understanding Physics of sun and solar system: photosphere, chromosphere, corona, solar activity. Solar MHD, helioseismology, solar system and its origin. Nebular model. ● Tidal forces and planetary rings. ● Understanding Physics of stars and sun. Role of gravitation in astroPhysics, Newton vs Einstein, viral theorem and thermodynamic equilibrium. Atomic spectra, stellar spectra. ● Spectral classification, luminosity classification, temperature dependence. ● Acquire basic knowledge of galaxies and Milky Way. Morphology and classification of galaxies, intrinsic stages of galaxies, galactic halo, milky way, gas and dust in galaxy, spiral arm, rotation of galaxy and dark matter. Star clusters in Milky Way, galactic nucleus and its properties.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Astronomical Scales:** Astronomical Distance, Mass and Time, Scales, Brightness,Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.	20
2	**Astronomical techniques:** Basic Optical Definitions for Astronomy (MagnificationLight Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).	25

	Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium. **The sun** (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere.Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: TheNebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **Stellar spectra and classification Structure** (Atomic Spectra Revisited, Stellar Spectra,Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)	
3	**The milky way** : Basic Structure and Properties of the Milky Way, Nature of Rotation ofthe Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.	15
4	**Galaxies**: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms. **Large scale structure & expanding universe**: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).	15

TEXT BOOKS

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Private limited, New Delhi,2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Embedded systems- Introduction to Microcontroller

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Embedded systems- Introduction to Microcontroller</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 604 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: Basic Electronics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Embedded Systems Intel microprocessor 8085, Intel 8051 microcontroller, architecture, instruction set, programming and its memory organization, timing diagram, Input/output operations and manipulation for arithmetic and logical operations, Programming with and without interrupt service request, Interfacing parallel and serial ADC and DAC, Embedded system development and product development</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn the architecture of embedded systems, their classification and application.
● Learn about the microprocessors and the organization of microprocessor based systems.
● Acquire knowledge of microcontrollers and their role in 1/0 port programming and their interface with peripherals.
● Learn about analog to digital and digital to analog convertors.
● Learn basics of Arduino and programming.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the successful completion of the course the student is expected to master the following:
● Embedded systems including its generic architecture, design and classifications,
● Embedded processors and microcontrollers.
● Organization of intel microprocessor 8085, its architecture, pin diagram, timing diagram, instruction set and programming in assembly language.
● Organization of Intel 8051 microcontroller, its architecture, instruction set, programming and its memory organization, timing diagram.</td></tr>
</table>

	● Input/output operations and manipulation for arithmetic and logical operations.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Embedded system introduction**: Introduction to embedded systems and generalpurpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers. **Review of microprocessors:** Organization of Microprocessor based system, 8085µp pindiagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **8051 microcontroller**: Introduction and block diagram of 8051 microcontroller,architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) registr, Jump, loop and call instructions.	20
2	**8051 I/O port programming**: Introduction of I/O port programming, pin out diagram of8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. **Programming**: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.	20
3	**Timer and counter programming**: Programming 8051 timers, counter programming. **Serial port programming with and without interrupt**: Introduction to 8051 interrupts, programming timer interrupts, programming external	17

	hardware interrupts and serial communication interrupt, interrupt priority in the 8051. **Interfacing 8051 microcontroller to peripherals**: Parallel and serial ADC, DAC interfacing, LCD interfacing.	
4	**Programming Embedded Systems**: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **Embedded system design and development:** Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. **Introduction to Arduino:** Pin diagram and description of Arduino UNO. Basic programming	18

TEXT BOOKS

- Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008,Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G.
- Mazidi, and R.D. McKinlay, 2 nd Ed., 2007, Pearson Education India.
- Embedded microcomputer system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
- Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
- Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, C engage Learning

SEC PAPERS

Physics Workshop Skills

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Physics Workshop Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 301 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at introducing to make simple length, height, time, area, volume measurements, mechanical skills needed to the workshop practice, Electrical and electronics skills related to the measurement of various electrical and electronics quantities.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn to use mechanical tools to make simple measurement of length, height, time, area and volume.
● Obtain hand on experience of workshop practice by doing casting, foundry, machining, welding and learn to use various machine tool like lathe shaper, milling and drilling machines etc. and working with wooden and metal blocks.
● Learn to use various instruments for making electrical and electronics measurements using multimeter, oscilloscopes, power supply, electronic switches and relays.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the successful completion of the course the student is expected to acquire skills/ hands on experience / working knowledge on various machine tools, lathes, shapers, drilling machines, cutting tools, welding sets and also in different gear systems, pulleys etc. He /she will also acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction:** Measuring units. conversion to SI and CGS. Familiarization with meterscale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.	12
2	**Mechanical Skill:** Concept of workshop practice. Overview of manufacturing methods:casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.	18
3	**Electrical and Electronic Skill:** Use of Multimeter. Soldering of electrical circuitshaving discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.	18
4	**Introduction to prime movers:** Mechanism, gear system, wheel, Fixing of gears withmotor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.	12

TEXT BOOKS

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

Applied Optics

Scheme Version: 2021-26	Name of the subject: Mechanical Drawing	L	T	P	C	Semester: III	Contact Hours per Week: 4
		0	0	4	2		Total Hours: 60
Subject Code: SBS PHY 03 302 SE 0042	Applicable to Program: Integrated B.Sc. M.Sc. (Physics)	Evaluation (Total Marks: 50)	CIE	15 Marks	Examination Duration: 3 hours (Practical only)		
			TEE	35 Marks	Prerequisite of Course: None		
Course Description	This course aims at providing knowledge of Sources and Detectors, Fourier Optics, Holography and Photonics: Fibre Optics						
Course Objectives	• This course will help in understanding about the lasers and detectors, Holography, Optical fibre and their applications.						
Course Outcomes	This course will enable the student to get: • Familiar with optical phenomena and technology. • Qualitative understanding of basic lasing mechanism, types of Lasers, characteristics of Laser Light, types of Lasers, and its applications in developing LED, Holography. • The idea of propagation of electromagnetic wave in a nonlinear media – Fibre optics as an example will enable the student to practice thinking in a logical process, which is essential in science. • Experiments in this course will allow the students to discuss in peer groups to develop their cooperative skills and reinforce their understanding of concepts.						
COURSE SYLLABUS							
Unit No.	Content of Each Unit					Hours of Each Unit	

1	**Sources and Detectors** Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers. **Experiments on Lasers:** a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser. b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser. c. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser **Experiments on Semiconductor Sources and Detectors:** a. V-I characteristics of LED b. Study the characteristics of solid state laser c. Study the characteristics of LDR d. Photovoltaic Cell e. Characteristics of IR sensor	15
2	**Fourier Optics** Concept of Spatial frequency filtering, Fourier transforming property of a thin lens **Experiments on Fourier Optics:** **a. Fourier optic and image processing** 1. Optical image addition/subtraction 2. Optical image differentiation 3. Fourier optical filtering 4. Construction of an optical 4f system **b. Fourier Transform Spectroscopy** Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science. **Experiment:** 1. To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the	15

	transmission characteristics of several interference filters. Computer simulation can also be done.	
3	**Holography** Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition **Experiments on Holography and interferometry:** 1. Recording and reconstructing holograms 2. Constructing a Michelson interferometer or a Fabry Perot interferometer 3. Measuring the refractive index of air 4. Constructing a Sagnac interferometer 5. Constructing a Mach-Zehnder interferometer 6. White light Hologram	15
4	**Photonics: Fibre Optics** Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating **Experiments on Photonics: Fibre Optics** a. To measure the numerical aperture of an optical fibre b. To study the variation of the bending loss in a multimode fibre c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern d. To measure the near field intensity profile of a fibre and study its refractive index profile e. To determine the power loss at a splice between two multimode fibre	15
TEXT BOOKS		
• Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill. • ASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill • Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books • Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier. • Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer. • Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd. • Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd. • Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press		

Basic Instrumentation Skills

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject: Basic Instrumentation Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS SBS PHY 03 501 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Develop skills to use basic electrical instruments like multimeter, electronic voltmeter, cathode ray, and oscilloscope.
● Acquire efficiency in making signal generators and analysis of obtained signals.
● Learn to understand and use various types of digital instruments.
● Develop knowledge of making measurements with Impedance Bridges and Q meters.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the successful completion of the course the student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements. He/she will acquire hands on skills in the usage of oscilloscopes, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes. He/she also would have gained knowledge on the working and operations of LCR Bridge, generators, digital meters and counters.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC milli voltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.	15
2	**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.	15
3	**Signal Generators and Analysis Instruments:** Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **Impedance Bridges & Q-Meters:** Block diagram of bridge. working principles of basic(balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.	15
4	**Digital Instruments:** Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **Digital Multimeter:** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.	15
TEXT BOOKS		

- Text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

The test of lab skills will be of the following test items:
1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:
1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:
1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Renewable Energy and Energy Harvesting

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Renewable Energy and Energy Harvesting</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours: 30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 402 SE 2002</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Fossil fuels and Alternate Sources of Energy, Solar energy, Wind Energy harvesting, Ocean Energy, Geothermal Energy, Hydro Energy, Piezoelectric Energy Harvesting, and Electromagnetic Energy Harvesting.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible.
● In this course student will study non –conventional energy sources and their practical applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● The students are expected to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.
● Learn about piezoelectricity, carbon- captured technologies like cells, batteries.
● The students should observe practical demonstrations of (i) training modules of solar energy, wind energy etc., (ii) Conversion of vibration into voltage using piezoelectric materials, (iv) conversion of thermal energy into voltage using thermoelectric modules.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional</td><td>8</td></tr>
</table>

	energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **Solar energy:** Solar energy, its importance, storage of solar energy, solar pond, nonconvective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	
2	**Wind Energy harvesting:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **Ocean Energy:** Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	8
3	**Geothermal Energy:** Geothermal Resources, Geothermal Technologies. Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.	7
4	**Piezoelectric Energy harvesting:** Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric Energy harvesting applications, Human power. **Electromagnetic Energy Harvesting:** Linear generators, physics mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.	7

TEXT BOOKS

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

Computational Physics Skills

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Computational Physics Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 401 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

#	Contents	Hours
1	**Introduction:** Importance of computers in Physics, the paradigm for solving physics problems for solution. Usage of Linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (i) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **Scientific Programming:** Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character, and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.	20

2	**Control Statements:** Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DOWHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.	20
3	**Scientific word processing:** Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.	10
4	**Visualization:** Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user-defined variables and functions), Understanding data with Gnuplot	10

TEXT BOOKS

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).
- LaTeX–A Document Preparation System”, Leslie Lamport (Second Edition, AddisonWesley, 1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
- Schaum’s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.

- Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
- A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed., 2007, Wiley India Edition.

Programming Exercises:

1. Exercises on syntax on the usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all-natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

Hands-on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation, etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write a program to open a file and generate data for plotting using Gnuplot.
6. Plotting the trajectory of a projectile projected horizontally.
7. Plotting the trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of the equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of a particle in a central force field and plot the output for visualization.

Weather Forecasting

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Weather Forecasting</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours:
30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 502 SE 2002</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting technique.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of classical mechanics
● To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
● To aware the students about applications of classical mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
● To learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
● Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall. Absorption, emission and scattering of radiations in atmosphere. Radiation laws.
● Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.</td></tr>
</table>

	● Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain. ● Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction to atmosphere:** Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.	8
2	**Measuring the weather**: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws. **Weather systems**: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.	8
3	**Climate and Climate Change**: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.	7
4	**Basics of weather forecasting**: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.	7

TEXT BOOKS

- Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
- The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
- Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
- Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
- Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.
- Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

LIST OF DEMONSTRATIONS AND EXPERIMENTS

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
(a) To calculate the sunniest time of the year.
(b) To study the variation of rainfall amount and intensity by wind direction.
(c) To observe the sunniest/driest day of the week.
(d) To examine the maximum and minimum temperature throughout the year.
(e) To evaluate the relative humidity of the day.
(f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

Electrical Circuits and Network Skills

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Electrical Circuits and Network Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week:
2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 601 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Design and troubleshoot the electrical circuits, networks and appliances through hands on mode.
● Build the basic foundation for learning electrical wirings and repairing of other house hold equipment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Design and troubleshoot certain electrical circuits and domestic appliances along with the understanding of the working of those appliances.
● Do electrical wiring and repairing.
● This knowledge will develop the skill of the students for various electrical repairing and servicing purposes.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC</td><td>8</td></tr>
</table>

	Electricity and DC, Electricity. Familiarization with multimeter, voltmeter and ammeter **Understanding Electrical Circuits:** Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money	
2	**Electrical Drawing and Symbols:** Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **Generators and Transformers:** DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.	8
3	**Electric Motors:** Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heater and motors, speed and power of ac motor. **Solid state devices:** Resistors, inductors and capacitors, Diode and rectifiers, Components in series or in shunt, Response of Inductors and capacitors with AC or DC sources.	7
4	**Electrical Protections:** Relays, fuses and disconnect switches, Circuit breakers, Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **Electrical Wiring:** Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.	7

TEXT BOOKS

- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBS Edn.

Radiation Safety

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Radiation Safety</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VI</td><td>Contact Hours per Week: 2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours:
30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 602 SE 2002</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Basics of Atomic and Nuclear Physics, Interaction of Radiation with matter: Types of Radiation, Radiation detection and monitoring devices: Radiation Quantities and Units, Radiation safety managemens, Application of nuclear techniques.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● General concepts of nuclei, nuclear forces and atomic physics are studied.
● Basic knowledge about nuclear radiation types and radiation detectors.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● Be aware and understand the hazards of radiation and the safety measures to guard against these hazards.
● Revise or learn the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.
● Have a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.
● Know about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Basics of Atomic and Nuclear Physics**: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.	7
2	**Interaction of Radiation with matter:** Types of Radiation: Alpha, Beta, Gamma andNeutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.	7
3	**Radiation detection and monitoring devices**: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire ProportionalCounters (MWPC) and Gieger Muller Counter), Scintillation Detectors(Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.	8
4	**Radiation safety management**: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. **Application of nuclear techniques:** Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial	8

	Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.	

TEXT BOOKS

- W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)
- G.F.Knoll, Radiation detection and measurements
- Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
- W.J. Meredith and J.B. Massey, “Fundamental Physics of Radiology”. John Wright and Sons, UK, 1989.
- J.R. Greening, “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
- Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
- A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981

GE PAPERS [Physics]

Mechanics [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Mechanics [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 101 GE 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce elementary concepts of Mechanics to the students so that they are able to understand fundamental aspects of forces, nature of forces and their applications. Objective here is that with the comparatively advanced mathematics tools than their high school curriculum, they will be able to apply these concepts in other branches of Physics and Science in general.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of Physics
● To get familiar with various concepts of mechanical problems related to Gravitational Force, spring force and oscillations.
● To inform the students about applications of mechanics in other science branches.
● To have a clear understanding about concepts related to space, time and relative motion.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the fundamentals of dynamics in constant as well as variable mass systems
● Learn about various concepts related to rotational dynamics and elasticity.
● Learn about gravitational force and spring force
● Understand the basic inception of space and time, and relative motion in inertial as well as non-inertial frames.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **Ordinary Differential Equations:** 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **Laws of Motion:** Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.	18
2	**Rotational Motion:** Angular velocity and angular momentum. Torque. Conservation of angular momentum. **Gravitation:** Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.	15
3	**Oscillations:** Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **Elasticity:** Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method.	15
4	**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.	12

TEXT BOOKS
● University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley ● Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill. ● Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley ● Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press ● University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Note: Students may not be familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Mechanics Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Mechanics Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 102 GE 0044</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.</td><td>60</td></tr>
</table>

	6. To determine the Elastic Constants of a Wire by Searle's method. 7. To determine g by Bar Pendulum. 8. To determine g by Kater's Pendulum. 9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Electricity and Magnetism [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Electricity and Magnetism [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 201 GE 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Electricity and Magnetism which covers the topics of Electric Field and Electric Potential, Electrostatic energy of system of charges, Dielectric Properties of Matter, Magnetic Field, Magnetic Properties of Matter, Electromagnetic Induction, Electrical Circuits, Network Theorems and Ballistic Galvanometer</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course will help in understanding basic concepts of electricity and magnetism and their applications.
● Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, the student should be able to
● Demonstrate Coulomb’s law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
● Explain and differentiate the vector (electric fields, Coulomb’s law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
● Apply Gauss’s law of electrostatics to solve a variety of problems.
● Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Vector Analysis:** Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).	12
2	**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	18
3	**Magnetostatics:** Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. **Magnetic properties of materials:** Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.	15
4	**Electromagnetic Induction:** Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **Maxwell`s equations and Electromagnetic wave propagation:** Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.	15

TEXT BOOKS

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press

- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

Note: Students may not be familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Electricity and Magnetism Laboratory [GE]

Scheme Version: 2021-26	**Name of the subject:** Electricity and Magnetism Laboratory [GE]	**L**	**T**	**P**	**C**	**Semester:** II	**Contact Hours per Week:** 4
		0	0	4	2		**Total Hours:** 60
Subject Code: SBS PHY 03 202 GE 0044	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 50)**	**CIE**	15 Marks	**Examination Duration:** 3 hours (Practical)		
			TEE	35 Marks	**Prerequisite of Course:** None		

#	List of Experiments	Hours
1	1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses. (e) Measurement of charge and current sensitivity and Measurement of CDR 2. Determine a high resistance by Leakage Method 3. To determine Self Inductance of a Coil by Rayleigh's Method. 4. To compare capacitances using De'Sauty's bridge. 5. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx) 6. To study the Characteristics of a Series RC Circuit. 7. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor	60

	8. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q 9. To determine a Low Resistance by Carey Foster's Bridge. 10. To verify the Thevenin and Norton theorems 11. To verify the Superposition, and Maximum Power Transfer Theorems	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Waves and Optics [GE]

Scheme Version: 2021-26	Name of the subject: Waves and Optics [GE]	L	T	P	C	Semester: III	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS PHY 03 301 GE 4004	Applicable to Program: Integrated B.Sc. M.Sc. (Physics)	Evaluation (Total Marks: 100)	CIE	30 Marks	Examination Duration: 3 hours (Theory)		
			TEE	70 Marks	Prerequisite of Course: None		
Course Description	This course is intended to introduce the student to a broad range of physical phenomena involving waves (including mechanical waves, sound waves, and electromagnetic waves), coherence, interference and diffraction phenomena						
Course Objectives	● Learn the basics of wave motion. ● Know about the behavior of light due to its wave nature. ● Identify and understand different phenomena due to the interaction of light with light and matter. ● Analyze some of the fundamental laws and principles of light which is used in many important optical instruments.						
Course Outcomes	After completion of this course, students would be able to: ● Enable the students to analyze different phenomena due to the interaction of light with light and matter. ● Train the students to use different optical instruments. ● Help the students to understand various natural phenomena using different apparatus in the laboratory.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit

1	**Superposition of Two Collinear Harmonic oscillations:** Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **Superposition of Two Perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **Waves Motion- General:** Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.	15
2	**Fluids:** Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication. **Sound:** Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.	15
3	**Wave Optics:** Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **Interference:** Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **Michelson's Interferometer:** Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.	15
4	**Diffraction:** Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.(5 Lectures)	15

<table>
<tr><th>TEXT BOOKS</th></tr>
<tr><td>● Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
● Principles of Optics, B.K. Mathur, 1995, Gopal Printing
● Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
● University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley</td></tr>
</table>

Waves and Optics Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Waves and Optics Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 302 GE 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde’s Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light</td><td>60</td></tr>
</table>

	8. To determine the value of Cauchy Constants. 9. To determine the Resolving Power of a Prism. 10. To determine wavelength of sodium light using Fresnel Biprism. 11. To determine wavelength of sodium light using Newton's Rings. 12. To determine the wavelength of Laser light using Diffraction of Single Slit. 13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating 14. To determine the Resolving Power of a Plane Diffraction Grating. 15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Modern Physics [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Modern Physics [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 401 GE 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of One dimensional potential problem of bound states and scattering and elementary introduction of nuclear physics with emphasis on

(i) Nuclear Structure
(ii) Nuclear Forces
(iii) Nuclear Decays
(iv) Fission and Fusion</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To Comprehend the failure of classical physics and need for quantum physics.
● To Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.
● To Formulate the basic theoretical problems in one, two and three dimensional physics and solve them.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
● Understand the theory of quantum measurements, wave packets and uncertainty principle.
● Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques,</td></tr>
</table>

	skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier. ● Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	18
2	Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.	12
3	One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potentialbarrier. Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.	15
4	Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half life α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor:	15

	slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.	

TEXT BOOKS

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
- Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning
- Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

Modern Physics Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Modern Physics Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 402 GE 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Measurement of Planck’s constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum
energy of photo-electrons versus frequency of light</td><td>60</td></tr>
</table>

	3. To determine work function of material of filament of directly heated vacuum diode. 4. To determine the Planck's constant using LEDs of at least 4 different colours. 5. To determine the wavelength of H-alpha emission line of Hydrogen atom. 6. To determine the ionization potential of mercury. 7. To determine the absorption lines in the rotational spectrum of Iodine vapour. 8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet. 9. To setup the Millikan oil drop apparatus and determine the charge of an electron. 10. To show the tunneling effect in tunnel diode using I-V characteristics. 11. To determine the wavelength of laser source using diffraction of single slit. 12. To determine the wavelength of laser source using diffraction of double slits. 13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Ability Enhancement Compulsory Courses (AECC)

English Communication

Scheme Version: 2021-26	Name of the subject: English Communication	L	T	P	C	Semester: I/II	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS ENG 0207 AECC 4004	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction**: Theory of Communication, Types and modes of Communication **Language of Communication**: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication	18
2	**Speaking Skills**: Monologue Dialogue Group Discussion Effective Communication/ Mis- Communication Interview Public Speech	14
3	**Reading and Understanding** Close Reading Comprehension Summary Paraphrasing Analysis and Interpretation Translation(from Indian language to English and vice-versa)	14

	Literary/Knowledge Texts	
4	**Writing Skills** Documenting Report Writing Making notes Letter writing	14
TEXT BOOKS		
1. *Fluency in English* - Part II, Oxford University Press, 2006. 2. *Business English*, Pearson, 2008. *3. Language, Literature and Creativity*, Orient Blackswan, 2013. 4. *Language through Literature* (forthcoming) ed. Dr. Gauri Mishra, Dr. Ranjana Kaul, Dr Brati Biswas		

Environmental Sciences

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

Environmental Sciences</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS EVS 0107 AECC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction to Environmental Sciences:** Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.	15
2	**Ecosystem: I**ntroduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem :- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems	15
3	**Biodiversity and its conservation**: Introduction – Definition, value and types: genetic, species and ecosystem diversity. Bio-geographical classification and Hot-spots of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation.	15
4	**Environmental issues and policies:** Definition, cause, effects and control measures of Air, Water, Soil, Marine and Noise pollution.	15

	Solid Waste Management: Causes, effects and control measures of wastes. Seventeen Sustainable Developmental Goals, Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, Public awareness.	
TEXT BOOKS		

1. Bharucha E, (2002) The Biodiversity of India, Mapin Publishing
2. Cao G, Orru R (2014) Current Environmental Issues and Challenges. 2014th edition; Springer
3. Cunningham W P, Cunningham M A (2008) Principles of Environment Science. Enquiry and Applications. 5th Edition. Tata McGraw Hill, New Delhi
4. Dash M C, Dash S P (2009) Fundamentals of Ecology. 3rd McGraw Hill Education
5. Gibbs J, Malcolm L, Sterling J (2008) Problem-Solving in Conservation Biology and Wildlife Management. 2nd ed. Wiley-Blackwell
6. Ginley D, Cahen, D (2011) Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press
7. Gilbert M (2007) An Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi
8. Khan I (2019) Forest Governance and Sustainable Resource Management. SAGE Publications. India.
9. Odum E P, Barrett W, (2005) Fundamentals of Ecology. 5th ed. Cengage Learning.
10. Sharma P D (2017) Ecology and Environment. 13th ed. Rastogi Publications
11. Thangadurai D, Ching G, Jeyabalan S, Islam S (2019) Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. United States: Apple Academic Press
12. Trivedi R K (2010) Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards, 3rd Edition. BS Publications

प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)
Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)

माध्यमः – संस्कृत/हिन्दी/आंग्लभाषा
Medium – Sanskrit/Hindi/English

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)
Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS SKT 0209 AECC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Obejctive</td><td colspan="7">1. संस्कृतेतर-विषयाणामध्येतृभ्यः संस्कृताध्ययनाय सौकर्योत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां वेदादि-शास्त्राणामुपनिषदां च रुचिरुत्पादनम्; 3. संस्कृतेनोपनिबद्धानां नीतिवाक्यानां गीतायां वर्णितस्य कर्मयोगस्य च तत्त्व-संधारणाय यत्नः; 4. सामान्य-भाषाविज्ञानस्य परिचयः।</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● अध्येतारः वेदादि-शास्त्राणामुपनिषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नशीलाः भवेयुः।
● व्यावहारिकदृष्ट्या संस्कृतज्ञानेन अन्यविषयाणामध्येतारः तत्तद् स्वविषयानुगुणं संस्कृतभाषायामुप- लभ्यमानानां ग्रन्थानां प्रति यत्नशीलाः स्युः।
● वेदोपनिषत्–गीता–नीतिशास्त्र–भाषाशास्त्रादीनां विषयाणां सम्यगध्ययनेनास्माकं पूर्वजानां वैदुष्येण परिचयः संजायेत।
● भारतीय-चिन्तनपरम्परायाः समृद्धिं ज्ञातुमयं पाठ्यक्रमः प्रकृष्टमाध्यमः संजायेत।</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)	15
2	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः	15
3	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भगवद्गीता – तृतीयाध्यायः (कर्मयोगः)	15
4	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – सामान्यभाषाविज्ञानम्- (क) वर्णमाला, वर्णानाम् उच्चारणस्थानानि प्रयत्नाश्च; (ख) भाषाविज्ञानस्य सामान्य परिचयः, भाषापरिवर्तनस्य कारणानि, अर्थपरिवर्तनस्य कारणानि च	15

TEXT BOOKS /अनुशंसितग्रन्थाः

1. उवव्ट-महीधर, शुक्लयजुर्वेदभाष्य, मोतीलाल बनारसीदास, दिल्ली, 2007
2. स्वामी दयानन्द सरस्वती, यजुर्वेदभाष्य, सम्पा० ब्रह्मदत्त जिज्ञासु, रामलाल कपूर ट्रस्ट, सोनीपत (हरियाणा)
3. तैत्तिरीयोपनिषद्, हिन्दी व्याख्याकार - स्वामी प्रखर प्रज्ञानन्द सरस्वती, काशी, 2013
4. भर्तृहरि, नीतिशतक, सम्पादक एवं हिन्दी व्याख्याकार - जनार्दन शास्त्री पाण्डेय, मोतीलाल बनारसीदास, दिल्ली, 2014
5. नीतिशतकम्, 'नीतिपथ' हिन्दी व्याख्याकार - राजेश्वर शास्त्री मुसलगाँवकर, चौखम्भा, वाराणसी
6. श्रीमद्भगवद्गीता (हिन्दी अनुवाद सहित), गीता प्रैस, गोरखपुर, 2015
7. श्रीकृष्ण त्रिपाठी, श्रीमद्भगवद्गीता (द्वितीय, तृतीय एवं चतुर्थ अध्याय), 2005
8. देवीदत्त शर्मा, भाषिकी और संस्कृत भाषा, हरियाणा साहित्य अकादमी, चण्डीगढ़, 1990
9. कपिलदेव द्विवेदी, भाषा-विज्ञान एवं भाषा-शास्त्र, विश्वविद्यालय प्रकाशन, चौक, वाराणसी, 2012
10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ
11. Burrow, T., The Sanskrit Language, 2016
12. Gune, P.D., An Introduction to Comparative Philology, Oriental Book House, Poona, 1958
13. The Taittirīya Upaniṣad, Eng. Tr. and Commentary by Swami Muni Narayana Prasad, D.k. Print world (P), Ltd., New Delhi-2009
14. The Nīti and Vairāgya Śatakas of Bhartrihari, M.R. Kale, Motilal Banarsidass, Delhi, 2017

हिंदी भाषा: रचना एवं व्यवहार

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

हिंदी भाषा: रचना एवं व्यवहार</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 203 AE 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Obejctive</td><td colspan="7">भाषा, व्याकरण एवं साहित्य के सामान्य स्वरूप का हिदर्शि ।</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• भाषा, बोली और व्याकरण के विविध घटकों का परिचय ।
• संचार माध्यमों के स्वरूप और भाषा का ज्ञान ।
• रचना पाठ से साहित्य बोध ।</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Unit–I भाषा और व्याकरण

भाषा की परिभाषा एवं विशेषताएं

भाषा और व्याकरण

हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)</td><td>15</td></tr>
</table>

2	**Unit –II हिंदी की संवैधानिक स्थिति** हिंदी भाषा व बोलियों का संक्षिप्त परिचय हिंदी की संवैधानिक स्थिति : राजभाषा, संपर्क भाषा और राष्ट्रभाषा कार्यालयी हिंदी : पल्लवन, संक्षेपण, टिप्पण पत्र लेखन : सरकारी, अर्द्ध-सरकारी	15
3	**Unit –III संचार माध्यमों का स्वरूप एवं भाषा** संचार माध्यमों का स्वरूप एवं भाषा संचार माध्यमों का सामाजिक प्रभाव कंप्यूटर में हिंदी का अनुप्रयोग	15
4	**Unit -IV** **कहानी : चंद्रधर शर्मा 'गुलेरी' :** उसने कहा था; **प्रेमचंद :** नशा **निबंध : हजारी प्रसाद द्विवेदी :** नाखून क्यों बढ़ते हैं; **बालमुकुंद गुप्त :** बनाम लार्ड कर्जन **कविता : सूर्यकांत त्रिपाठी 'निराला' :** वर दे, वीणा वादिनी वर दे ! **जयशंकर प्रसाद :** हिमाद्रि तुंग शृंग से	15

TEXT BOOKS /अनुशंसितग्रन्थाः

1. हिंदी : उद्भव, विकास और रूप; डॉ हरदेव बाहरी; किताब महल इलाहाबाद; 1969.
2. हिंदी भाषा; डॉ भोलानाथ तिवारी; किताब महल, इलाहाबाद; 2004.
3. हिंदी व्याकरण; कामता प्रसाद गुप्त; नागरी प्रचारिणी सभा, काशी; 1927.
4. व्यावहारिक हिंदी व्याकरण तथा रचना; हरदेव बाहरी; लोकभारती प्रकाशन, इलाहाबाद; 1972.
5. कंप्यूटर और हिंदी; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2015.
6. रेडियो और दूरदर्शन पत्रकारिता; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2017.

Course Contents

(for Semester VII to X)

Core Courses

Classical Mechanics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Classical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 701 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basic knowledge of mechanics and calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Classical Mechanics to the students so that they are able to understand the Lagrangian & Hamiltonian mechanics of systems of particles interacting with various forces and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of classical mechanics
● To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
● To aware the students about applications of classical mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the mechanics of system of particles, D'Alembert's principle, Lagrangian mechanics, & Euler's equation of motion.
● Learn about Hamiltonian formulation, Hamilton's Equations of Motion and Principle of least action.
● Learn Canonical Transformations & Hamilton-Jacobi theory.
● Learn about Rigid body dynamics including problems.
● Understand the two body central force problem and its related aspects.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Lagrangian Formulation and Central Force Problem:** Newtonian mechanics of one and many particle systems,Virtual work, Constraints: holonomic and non-holonomic,D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton's Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem. The Kepler Problem.	15
2	**Hamilton's Equations of Motion:** Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.	15
3	**Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variables, Adiabatic invariance of action variable, Applications of action angle variables: The Kepler problem	15
4	**Small Oscillations and Rigid Body Motion:** Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator. Orthogonal transformation, Eigenvalues of the inertia tensor, Euler equations, Eulerian angles, moment of Inertia. Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Coriolis force. Perturbation theory. Introduction to chaotic dynamics.	15

TEXT BOOKS

• Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
• Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
• A.Sommerfeld, Mechanics, Academic Press,United States, 1st Edition, 1952.
• I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1982.
• Ronald L. Greene, Classical Mechanics with Maple, Springer,Germany, 2nd Edition, 2000.
• N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1st Edition, 2015.
• Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
• Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

Advanced Mathematical Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Advanced Mathematical Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 702 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Undergraduate level Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge Linear Vector Spaces, Matrices, Cartesian Tensors, General Tensors and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● In this course, the students should the learn the skills of doing calculations with the linear vector space, matrices, their eigenvalues and eigenvectors, tensors, real and complex fields, linear and multilinear transformations in various physical situations, e.g., the Lorentz transformations etc.
● They also become efficient in doing calculations with the ‘calculus of variation’.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
● Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g, operators in quantum mechanics. They should also learn how to find eigenvalues and eigenvectors of matrices.
● Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor, etc.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Linear Vector Spaces:** Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.	12
2	**Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product. Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix	18
3	**Cartesian Tensors:** Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.	18

4	**General Tensors:** Transformation of Coordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Metric Tensor.	12

TEXT BOOKS

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicists & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence,3rd Ed., 2006, Cambridge University Press

Advanced Quantum Mechanics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Advanced Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 703 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Undergraduate level Mathematical Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand some advanced topics such as symmetries, identical particles, approximation methods and relativity in quantum mechanics, which has broad and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To make familiar with various advanced topics of quantum mechanics such as symmetries and conservation laws, fermions and bosons, time independent and time dependent perturbation theories, variational and WKB methods, scattering theory, delta function and relativistic theory
● To aware the students about applications of advanced phenomena of quantum mechanics in physical, mathematical and chemical sciences</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students will be able to
● understand the concepts of symmetries, conservation laws, bosons and fermions in quantum mechanics
● apply symmetries and conservation laws in various quantum mechanical problems
● illustrate the time independent and time dependent perturbation theories, the variational and WKB methods
● describe the fine structure and Zeeman effect phenomena
● explain the basics of scattering theory
● apply the delta function’s properties in various quantum mechanical problems
● understand the basics of relativistic quantum mechanics</td></tr>
</table>

	• recognize the importance and applications of relativistic quantum mechanics determine the transmission and reflection coefficients of potential barrier and well, potential step, and delta function well • recognize the importance of angular momentum and its applications in quantum mechanics • explain the physics behind the addition of angular momenta	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Structure of Quantum Mechanics:** Notion of state vector. Probability interpretation. Operators and observables, operators as matrices, significance of eigenvalues and eigenfunctions. Commutation relations. Measurement in quantum theory. **Symmetry and Angular momentum Algebra:** Symmetry operations and unitary transformations. Conservation laws. Space and time translations; rotation. Discrete symmetries: Space inversion, time reversal and charge conjugation. Symmetry and degeneracy. Rotation operator, generators of infinitesimal rotation, angular momentum algebra, eigenvalues of J^2 and J_z. Pauli matrices and spinors. Addition of angular momenta. Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Slater determinants, Pauli exclusion principle.	18
2	**Time-independent Approximation Methods:** Non-degenerate and degenerate perturbation theory. Stark effect, Zeeman effect and other examples. Variational methods. WKB approximation. Tunneling. Numerical perturbation theory, comparison with analytical results.	15
3	**Time-dependent Problems:** Schrödinger and Heisenberg pictures. Time-dependent perturbation theory. Transition probability calculations, Fermi's golden rule. Adiabatic and sudden approximations. Introduction to the quantization of electromagnetic field.	15
4	**Relativistic Quantum Mechanics:** Klein-Gordon equation, Dirac equation, Probability and Current Density, Plane Wave Solutions, Symmetries of the Dirac equation, Dirac's Equation for a Central Potential, Covariance of Dirac's Equation, Relativistic Hydrogen Atom Problem, The Hole Theory and Positrons. **Interaction:** Yukawa interaction, Coupling of electron and electromagnetic field, Feynman diagrams, Feynman rules, Path	12

	integration method: Probability amplitude as path integral, action, free particle and harmonic oscillator motion, Wick's Theorem. Scattering matrix.	

TEXT BOOKS

1. L. D. Landau and E.M. Lifshitz, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3^{rd} Edition, 1981.
2. P. A. M. Dirac, The Principles of Quantum Mechanics, Oxford University Press, UK, 4^{th} Edition, 1988.
3. R. Shankar, Principles of Quantum Mechanics, Springer, Germany, 2^{nd} Edition, 1994.
4. N. Zettili, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2^{nd} Edition, 2009.
5. J. J. Sakurai, Modern Quantum Mechanics, Pearson, India, 2^{nd} Edition, 2013.
6. L. I. Schiff, Quantum Mechanics, McGraw Hill Education, USA, 4^{th} Edition, 2017.
7. D. J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3^{rd} Edition, 2018.
8. C. Cohen-Tannoudji, B. Diu, and F. Laloe, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2^{nd} Edition, 2019.
9. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
10. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

Physics Laboratory-VII

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

Physics Laboratory-VII</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 105 CC 00126</td><td rowspan="2">Applicable to Programs:

Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:

3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the laboratory is to train students to perform various experiments associated with Electronics, Quantum physics, Waves mechanics and Spectroscopy. Students assigned the general laboratory work will perform at least ten (10) experiments of the above mentioned list of Physics experiments and further 8 experiments from the C programming section.. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To give hands-on experience to students for generating magnetic field and measurement of various parameters.
● To teach how temperature controlled oven works
● To take measurements of current and voltage using various equipment</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to

● learn various Physics aspects by performing the experiments related to electronic devices, atomic and molecular physics, light wave, sound waves etc.
● Learn Error analysis
● Use excel for plotting graphs
● to do C/C++ programming</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	1. Hall Effect 2. Four Probe Method to find band gap of semiconductor 3. Electron Spin Resonance 4. Frank-Hertz experiment 5. PN Junction characteristics 6. Solar cell characteristics 7. Velocity of ultrasonic wave in liquids 8. Characteristics of MOSFET 9. Diode as voltage regulator 10. Ionization potential of mercury 11. Planck's constant using LED 12. Law of Malus 13. Zener diode characteristics	150
2	Review of C/C++ Programming: 1. Write a Program to calculate and display the volume of a CUBE having its height, width and depth. 2. Write a C program to perform addition, subtraction, division and multiplication of two numbers 3. Write a program to input two numbers and display the maximum number. 4. Write a program to find the largest and smallest among three entered numbers and also display whether the identified largest/smallest number is even or odd. 5. Write a program to find the roots of quadratic equation. 6. Write a program to check whether the entered year is leap year or not (a year is leap if it is divisible by 4 and divisible by 100 or 400.) 7. Write a program to find the factorial of a number. 8. Write a program to check number is Armstrong or not. 9. Write a program to find GCD (greatest common divisor or HCF) and LCM (least common multiple) of two numbers 10. Write a program to generate Fibonacci series.	30
TEXT BOOKS		
1. Worsnop and Flint, Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951. 2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.		

Classical Electrodynamics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Classical Electrodynamics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 801 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Undergraduate level Mathematical Physics and Electricity and Magnetism</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of basic electrodynamics and it’s applications to various phenomena.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of classical electrodynamics and four-vector formalism
• To get familiar with various concepts used in retarded potential theory.
• To aware the students about modern problems in classical electrodynamics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
• The students will have an understanding of boundary value problems in electrodynamics.
• The student will be able to learn the relativistic transformation of EM fields
• The students will be able to analyze radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate.
• The students will be able to learn advanced concepts of charge particle acceleration techniques.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Review of Electrostatics and Magnetostatics** Action-at-a distance vs. concept of fields, Poisson and Laplace equations and formal solution for scalar potential with Green's functions, boundary value problems; multipole expansion; Dielectrics, polarization of a medium; Clausius-Mossotti Relation, Electrostatic energy in dielectrics and Maxwell stress tensor, Magnetic multipole expansion of vector potential, Magnetization, Magnetostatic energy densities and Magnetic stress tensor	15
2	**Covariant Formulation of Electrodynamics** Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of **E** and **B**. Covariant formulation of Maxwell's equations, Equation of motion of charged particle, Motion of charged particles in external electric and magnetic fields.	15
3	**Electromagnetic Radiation:** Introduction to retarded potentials. Potentials due to a moving charge: Lienard Wiechert potentials. **E** and **B** due to a uniformly moving charge. **E** and **B** due to an accelerating charge particle: Power radiated, Larmor's formula and its relativistic generalization.	15
4	**Interaction of Matter with Charge Particles and Advanced Acceleration Techniques:** Radiation Bremsstrahlung and transition radiation, Thomson scattering, Synchrotron radiation and undulator radiation, Coherent emission from multiple particles, Coherence and Form factor, Radiation from relativistic particle traveling through matter: Cherenkov radiation	15
TEXT BOOKS		
● Classical Electrodynamics, J D Jackson, Wiley; Third edition, 2003 ● The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier ● Classical Electricity and Magnetism, W. K. H. Panofsky and M. Philips, Dover Publication, 2nd Edn, 2012 ● Modern Problems in Classical Electrodynamics, Chales A Brau, OUP USA, 2003 ● Classical Electrodynamics, S P Puri, Narosa Publishing; 2011 ● Introduction to Electrodynamics, D.J. Griffiths, 2018, Fourth Edition, Pearson Education ● Feynman Lectures, Vol. II, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education ● X-Rays and Extreme Ultraviolet Radiation: Principles and Applications, David Attwood, Cambridge University Press; 2nd edition, 2017		

Atomic and Molecular Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

Atomic and Molecular Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 802
CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Modern Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of the course is to aware students about various atomic and molecular spectra and to understand the working of LASERs.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The students will be exposed to
. Rotation and Vibration spectroscopy
. Raman Effect and Raman spectroscopy of molecules.
. Working of Lasers</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to :
● Understand different models of an Atom
● Derive the energy distribution corresponding to different levels of an atom
● Understand rotation spectroscopy and Understand Raman Effect and Raman spectroscopy of molecules.
● Understand the working of He-Ne Laser and Ruby Laser.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Atomic Spectra I: [Course Outcomes : CO301C.1]
Review of Atomic Models: Rutherford’s Model, Bohr’s model, Sommerfeld’s model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect.</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Atomic Spectra II: [Course Outcomes : CO301C.2]</td><td>15</td></tr>
</table>

	Spin-orbit interaction and fine structure, LS and JJ coupling, Relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the hydrogen atom spectra, Zeeman and Paschen-Back effect. Hyperfine structure and isotope shift, Auger Effect and Frank Condon Principle. Born-Oppenheimer approximation.	
3	**Molecular spectra: [Course Outcomes : CO301C.3]** Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, Vi vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy (Brief Introduction).	15
4	**Lasers: [Course Outcomes : CO301C.4]** Spontaneous and stimulated emission, Spatial and temporal Coherence, Einstein A and B coefficients, Optical Pumping, Population Inversion, Modes of resonator, Q-switching and Mode Locking, Ultra short pulse generation, He-Ne Laser and Ruby Laser-Principle, Construction and working, Application of lasers in the field of medicine and Industry.	15

Text Books

1. H. E. White, Introduction to Atomic Spectra, McGraw Hill, New York, 1st Edition, 1934.
2. H. G. Kuhn, Introduction to Atomic Spectra, Green and Co., Harlow, 2nd Edition, 1969.
3. K. Thyagarajan and A.K. Ghatak, Lasers - Theory and Applications, Plenum Press, New York, 1st Edition, 1981.
4. B. H.Bransden and C. J Joachain, Physics of Atoms and Molecules, Pearson, UK, 2nd Edition, 2003.
5. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, United States, 2nd Edition, 2006.
6. Arthur Beiser, Perspectives of Modern Physics, McGraw Hill, New York, 6th Edition, 2006.
7. C. N. Banwell, Fundamentals of Molecular Spectroscopy, McGraw Hill, New York, 4th Edition, 2017.

Nuclear Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Nuclear Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VIII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 803 CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course will enable the students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions. T</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Students will be exposed to
● General properties of nuclei
● Interactions among the nucleons
● Different models developed to explain the nuclear structure</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Understand basic properties of nuclei
● Understand interactions between nucleons, meson theory and spin dependence of nuclear forces
● Get knowledge about Nuclear models, Magic numbers, and Collective nuclear model.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Introductory Concept of Nuclei: Scattering and electromagnetic methods for determining the nuclear radius, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadrupole moment, Parity quantum number, Statistics of nuclear particles, Nuclear Disintegration: Simple</td><td>15</td></tr>
</table>

	theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.	
2	**Inter Nucleon Forces:** Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.	15
3	**Nuclear Structure and Models:** Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular moment, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi-empirical mass formula, Nuclear fission, The unified model.	15
4	**Heavy Ion Nuclear Reactions:** Total Hamiltonian function, Fusion fission dynamics, Radioactive ion beams, tightly and loosely bound interactions, Nuclear isomers, Nuclear Molecules, Nuclear Dynamics at Intermediate and high energies, Quantum Dynamics Models, Statistical Models, Multi-fragmentation, Elliptical Flow, Transverse Flow, Experimental Scenario, Relativistic heavy ion collisions	15

TEXT BOOKS

1. Roy & Nigam,Nuclear Physics, John Wiley & Sons, USA, 1st Edition, 1967.
2. H. Enge,Introduction to Nuclear Physics, Addison Wesley, USA, 1st Edition 1969.
3. J.M. Blatt and V.F. Weisskopf, Theoretical Nuclear Physics, Springer, Germany, 1st Edition, 1969.
4. M.Leon,Particle Physics:An introduction, Elsevier, Netherlands, 1st Edition, 1973.
5. S. N. Ghoshal, Nuclear Physics, S. Chand, India, 1st Edition, 1994.
6. F.I. Stancu, Group Theory in Subnuclear Physics, Clarendon Press, UK, 1st Edition, 1997.
7. J.D. Walecka,Theoretical Nuclear and Subnuclear Physics, World Scientific, Singapore, 2nd Edition, 2004.
8. B. R. Martin and G. Shaw,Particle Physics, John Wiley & Sons, USA, 3rd Edition, 2008.

Physics Laboratory-VIII

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

Physics Laboratory-VIII</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1^{st} Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 204 CC 00126</td><td rowspan="2">Applicable to Programs:

Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:

3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim & objective of the course is to impart the practical training on various electronics devices such as; Op-Amp, Vibrators, Amplifiers, Michelson interferometer etc. Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To train students for various electronics experiments and take measurements
● To train students on various optical instruments like Spectrometer, Michelson Interferometer
● To have hand on experiment for measurement of magnetoresistance and dielectric constant.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to

● Understand spectral lines, grating spectra, and interference fringes
● Learn the characteristics of Op-Amp, vibrators, clipper, clampers, and DA/ AD
● Use excel for plotting graphs
● Understand motion of temperature and magnetic field dependence of Hall coefficient.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Study of Balmer series and Rydberg constant 2. Op-Amp as inverting and non-inverting amplifier 3. Op-Amp as differentiator, Integrator and Adder 4. e/m by Thomson method 5. Single stage RC coupled amplifier 6. Frequency response of common emitter amplifier 7. Bistable/Monostable/Astable vibrators 8. Grating spectra 9. Refractive index of water and oil using prism 10. Magneto resistance 11. Temperature dependence of Hall coefficient 12. Digital to Analog converter, Analog to Digital converter 13. Michelson Interferometer 14. Faraday Effect 15. Clipper and clampers	150
2	1. Root finding of a polynomial equation using numerical methods 2. Solving first and second order differential equation numerical methods 3. Numerical integration 4. Generating finite and infinite series	30

TEXT BOOKS

1. Worsnop and Flint, Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951.
2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.
3. Lab manuals, prepared by faculty of the Department of Physics and Astrophysics, 2018.

Condensed Matter Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Condensed Matter Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 03 901 CC 4004</td><td rowspan="2">Applicable to Programs:

Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Solid State Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">Solid state physics is the branch of physics dealing with physical properties of solids particularly crystals, including the behavior of electrons in these solids. The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.
● To develop the scientific and positive attitudes in students related to the materials science which is a part of solid state physics
● To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to

● identify various crystal structures and their symmetries in solids
● determine the crystal structure through X-ray diffraction, rotating crystal, and Laue methods
● explain the theories and phenomena of lattice dynamics, various bonding, and thermal properties (specifically specific heat) in solids
● calculate the specific heat and density of states of various solids</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">● interpret the electrical conductivity and resistivity, mean free path, relaxation time, Fermi energy, electronic specific heat, and band formation in solids
● recognize the importance of effective mass, nearly free-electron model and tight binding approximation
● identify the basic differences between conductors and superconductors
● illustrate the some exciting phenomena such as Meissner effect, Isotope effect, London’s equations, BCS theory, and Josephson effect of superconductors
● understand the basics of high temperature superconductors and commercial applications of superconductors</td></tr>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>Crystal Structure: Crystal Structures and Lattices with Basis, Miller Indices, Common Crystal Structures, Reciprocal Lattice, Brillouin Zones, X-ray Diffraction by a Crystal and Their Equivalence, Laue Equations, Ewald Construction, Brillouin Interpretation, Intensity of X-ray Reflections: Atomic Scattering Factor; Geometrical Structure Factor, Structure Factors, Structure Factor; Experimental Methods of Structure Analysis: Laue’s Method; Rotating Crystal Method; Powder Method, Diffraction from Non-Crystalline Systems.</td><td>15</td></tr>
<tr><td>2</td><td>Lattice Dynamics, Crystal Binding and Thermal Properties: Classical Theory of Lattice Dynamics: Vibrations of Crystals with Monatomic Basis and Two Atomic Basis; Dispersion Relation; Group Velocity; Acoustical and Optical modes, Bonding in Solids, Elastic Constants and Properties, Phonons: Quantization of Lattice Vibration; Phonon Momentum; Inelastic Scattering of Neutrons by Phonons, Thermal Properties: Heat Capacity; Density of States; Normal Modes; Debye and Einstein Models.</td><td>15</td></tr>
<tr><td>3</td><td>Free Electrons and Energy Band in Solids: Free Electron Gas Model and Its Limitations, Electrons Moving in One and Three Dimensional Potential Well, The Density of States, Fermi Energy, Effect of Temperature on Fermi Distribution Function, The Electronic Specific Heat, The Electrical Conductivity of Metals,</td><td>15</td></tr>
</table>

	Relaxation Time and Mean Free Path, The Electrical Resistivity, Band Theory:Bloch Theorem; The Kronig-Penny Model; Symmetry Properties of the Energy Function; Effective Mass of an Electron; The Nearly Free Electron Model and Tight Binding Approximation; Metals; Insulators and Semiconductors.	
4	**Superconductivity : I**ntroduction to Superconductivity, Effect of Magnetic Field, The Meissner Effect, Type I and Type II Superconductors, Entropy, Free Energy, Heat Capacity, Energy gap, Isotope Effect, Thermodynamics of the Superconducting Transition, London Equation and Penetration Depth, Coherence Length, BCS Theory of Superconductivity, Cooper Pair, Flux Quantization, DC and AC Josephson Effects: SQUIDs, High Temperature Superconductivity, Applications of Superconductors.	15

TEXT BOOKS

1. J. M. Ziman, Principles of the Theory of Solids, Cambridge University Press, UK, 2nd Edition, 1979.
2. J. F. Annett, Superconductivity Super fluids and Condensates, Oxford University Press, UK, 1st Edition, 2004.
3. J. P. Srivastava, Elements of Solid State Physics, Prentice-Hall of India, 2nd Edition, 2006.
4. H. Ibach and H. Luth, Solid State Physics: An Introduction to Theory and Experiment, Springer, Germany, 4th Edition, 2009.
5. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publications, India, 2nd Edition, 2009.
6. C. Kittel, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Holt, Rinehart and Winston, USA, Revised Edition, 2016.
8. S. O. Pillai, Solid State Physics, New Age International Publishers, 8th Edition, 2018.

Particle Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 902 CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics, Quantum Physics and Nuclear Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart the knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Students will understand the different type of particles and interactions among them
● Students will be able to understand the conservation laws in particle physics
● Students will get to know the production cross section for particles
● Students will understand the quark model.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Need of standard model and its limitations and the properties of QCD.
● Basic rules of Feynman diagrams and the quark model for hadrons
● Properties of neutrons and protons in terms of a simple quark model
● Weak interaction between quarks and how that this is responsible for β decay.
● Leptons and how the (electron) neutrinos and (electron) antineutrinos are produced during β+ and β- decays respectively</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Introduction:** Fermions and bosons, Particles and antiparticles, Quarks and leptons, Interactions and fields in particle physics, Classical and quantum pictures, Yukawa picture, Types of interactions - electromagnetic, weak, strong and gravitational, units.	15
2	**Invariance Principles and Conservation Laws:** Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem.	15
3	**Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy.	15
4	**Static Quark model of Hadrons:** The Eightfold way, Meson nonet, Baryon octet, Baryon Decuplet, hypothesis of quarks, SU (3) symmetry, Quark spin and color, Quark-antiquark combinations. **Weak Interactions:** Classification of weak interactions, Fermi theory, Weinberg-Salam model, Parity non-conservation in β-decay, Helicity of neutrino, Experimental verification of parity violation, K-decay.	15
TEXT BOOKS		

1. Perkins, D.H., Introduction to High Energy Physics, Cambridge University Press, 2000, 3rd Ed.
2. Hughes, I.S., Elementary Particles, Cambridge University Press, 1991.
3. Close, F.E., Introduction to Quarks and Partons, Academic Press, 1979.
4. Segre, E., Nuclei and Particles, Benjamin-Cummings, 1977.
5. Khanna, M.P., Introduction to Particle Physics, Prentice-Hall of India, 2004.

Physics Laboratory-IX

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Physics Laboratory-IX</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 903 CC 00126</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of Lab III is to train students for advanced practical problems related to solid state physics, nuclear physics, electronics, numerical techniques and material science.

Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To train students on advanced experiments
● To give training on advance instruments
● To introduce students to latest numerical techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Do some experiments based on nuclear physics, electronics, computation and solid state physics.
● Understand the basic synthesis and characterization techniques for different materials such as thin films and nanoparticles.
● Perform advanced experiments like DTA, TGA, UV-VIS, Microwave furnace and thin film coating techniques.
● Learn advance techniques of numerical analysis</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Kerr Effect 2. Curie Temperature 3. B-H curve 4. Dielectric constant 5. Solid State Nuclear Track Detector (SSNTD) 6. G.M. Counters: characteristics, dead time and counting statistics 7. Scintillation detector-energy calibration, resolution and determination of gamma ray energy 8. Quinck's tube method to find susceptibility of a material 9. Nuclear Magnetic Resonance 10. Zeeman Effect 11. To study Lattice Dynamics	100
2	**(i) Electronics** 1. PCM/delta modulation and demodulation 2. Fiber optic communication 3. Modulation/Demodulation 4. 4-bit ripple counter **(ii) Thin Film and Nano-Material** 1. Data Analysis of XRD, SEM and TEM 2. Chemical Deposition (for CNT growth) 3. ZnO wire by thermal oxidation 4. Band gap estimation by Tauc-plot method 5. Thin film deposition technique 6. DTA/TGA analysis **(iii) Numerical Techniques** 1. Solution of Linear algebraic equation: Gauss Jordan elimination, Singular Value Decomposition, Sparse linear system. 2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function. 3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness.	80

	4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data. 5. Eigen systems: Solving eigenvalues and finding eigenfunctions of Schrodinger equation for analytically unsolvable potentials using variational principle.	

TEXT BOOKS

1. Albert Malvino, Digital Principles and Applications, McGraw Hill, New York, 4th Edition, 1986.
2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.
3.W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.
4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, and Complexity, Oxford University Press, 2nd Edition, 2007.
5. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1st Edition, 2017.

DSE Courses

(for Semester VII to IX)

Statistical Mechanics-II

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject: Statistical Mechanics-II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 03 701 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Quantum Mechanics and Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is developed for understanding of thermodynamics and statistical mechanics, which have broad and rich applicability in quantum mechanics, condensed matter physics, classical mechanics and electrodynamics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the fundamentals of thermodynamics and statistical mechanics
To make familiar with various thermodynamical and statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.
To able the students for solve the problems related to thermodynamics and statistical physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
Explain the various thermodynamical quantities and Maxwell’s relations
Apply the thermodynamics in ideal gas, magnetic and dielectric materials
Describe various statistical approaches which describe systems of particles
Evaluate the formulae of random walk and diffusion equation</td></tr>
</table>

	● Compare microstates, macrostates, and statistical ensembles ● Understand the theories and mathematical approaches of statistical ensembles, equipartition theorem and Maxwell-Boltzmann statistics ● Illustrate the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics ● Calculate the problems related to Bosons and Fermions

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Review of Thermodynamics:** Extensive and intensive variables, laws of thermodynamics, Entropy for Different Systems, Gibbs Paradox, Boltzmann Relation for Entropy, Legendre Transformations and Thermodynamic Potentials, Chemical Potential, Free Energy and Its Connection with Thermodynamic Quantities, Maxwell Relations, Applications of Thermodynamics to (a) Ideal Gas, (b) Magnetic Material, and (c) Dielectric Material.	15
2	**Statistical Methods and Description of Systems of Particles:** Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem, Random Walk and Brownian Motion, Diffusion Equation, Phase Space, Liouville's Theorem, Phase Equilibrium, Microstates and Macrostates, Statistical Ensembles, Irreversibility and the Attainment of Equilibrium	15
3	**Classical Statistical Mechanics:** Micro-Canonical Ensemble, Canonical Ensemble: Derivation of Partition Function and Thermodynamic Quantities; Mean Values and Fluctuations, Grand Canonical Ensemble: Gibbs Factor; Gibbs Distribution; Derivation of Partition Function and Thermodynamic Quantities; Fluctuations in the Number of Particles, Applications of Canonical and Grand Canonical Ensembles, Equipartition Theorem and It's Applications, Maxwell-Boltzmann Statistics.	15
4	**Quantum Statistical Mechanics:** Bosons: Occupation Number; Bose-Einstein Statistics; Debye Theory of Specific	15

	Heat; Grand partition function For Ideal Bose Gas; Black-Body Radiation; Bose-Einstein Condensation, Fermions: Occupation Number; Fermi-Dirac Statistics; Ideal Fermi gas, Pauli Paramagnetism, First and Second Order Phase Transitions, Ising Model, Phase Equilibria: Equilibrium Conditions; Simple Phase Diagrams; Clausius-Clapeyron Equation.	

TEXT BOOKS

1. F. Reif, Fundamental of Statistical and Thermal Physics, McGraw-Hill, USA, 1965.
2. L. D. Landau and E. M. Lifshitz, Statistical Physics, UK, 3rd Edition, 1980.
3. D. V. Schroeder, An Introduction to Thermal Physics, Addison Wesley Longman, UK, 2000.
4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford University Press, UK, 2006.
5. M. Kardar, Statistical Physics of Particles, Cambridge University Press, UK, 2007.
6. H. Gould and J. Tobochnik, Statistical and Thermal Physics: With Computer Applications, Princeton University Press, USA, 2010.
7. K. Huang, Statistical Mechanics, Wiley, India, 2nd Edition, 2011.
8. R. K. Pathria and P. D. Beale, Statistical Mechanics, Academic Press, USA, 2011.

Introduction to Hydrogen Energy Systems

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:

Introduction to Hydrogen Energy Systems</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VII</td><td>Contact hours per week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 702 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks):
100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">To introduce the concept of energy generation from Hydrogen as future fuel. To enlighten the knowledge of production, storage and transportation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">This course aim is to give insight of hydrogen production, storage and their application, as a future source of energy.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues.
There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. By observing energy efficient measures there is tremendous scope of saving energy in industry, built environment, transport etc.
To teach fundamentals of hydrogen energy as energy systems, production processes, separation and utilization that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.
This course has objectives to elaborate PG students regarding current trends in hydrogen energy architecture and following key concepts such as hydrogen storage and hydrogen sensing.
To Provide adequate inputs on a variety of issues relating to safety guidelines, codes and standards in hydrogen energy systems.</td></tr>
<tr><td></td><td colspan="7">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
</table>

1.	**Hydrogen Energy Pathways-** Properties of hydrogen, Global and Indian hydrogen energy scenario, need for hydrogen, current uses, environmentally sustainable hydrogen, hydrogen as part of Climate Neutral Strategy. Hydrogen for mobility applications & vehicles, Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications.	15
2.	**Hydrogen Production**-Production of hydrogen from hydrocarbons-oxidative and nonoxidative processes, coal. Hydrogen production using nuclear energy and renewables- wind, biomass, solar. **Hydrogen separation and purification**-Pressure swing adsorption, Solvent based absorption, membrane separation, cryogenic separation etc.	15
3.	**Hydrogen Storage -**Types of hydrogen storage (Gaseous, Liquid, Solid hosts), Gibbs Phase Rule, Pressure-Composition-Temperature plots; Van't Hoff plots for absorption desorption enthalpies, Gravimetric capacities, Hysteresis in cycling, Joule-Thomson Effect, Non-ideal treatment of hydrogen gas Kinetics: Hydrogen absorption/desorption phenomena (chemisorption, nucleation and growth and diffusion), Kinetic models, Kissinger analysis for activation energy estimation, Hydrogen adsorption isotherms-BET, design and applications of storage systems, materials for hydrogen storage, Hydrogen storage for automobiles.	15
4.	**Hydrogen sensing-**Traditional methods of hydrogen sensing using thermal conductivity measurements or Gas Chromatography, Mass Spectroscopy or laser gas analysis; Solid state sensors- their working principle and applications at industrial scale. **Hydrogen Safety-**Physiological, physical and chemical hazards, hydrogen properties associated with hazards, Hazard spotting, evaluation and safety guidelines, Hydrogen safety codes and standards. Hydrogen safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management.	15

REFERENCE BOOKS

1. F. Peter, Fuels and Fuel Technology, A.Wheatan & Co. Ltd., 1st edition, 1965.
2. JOM Bockris, Energy options: Real Economics and the Solar Hydrogen System, Halsted Press and London publisher, 1980.
3. S. Sarkar, Fuels and Combustion, Orient Longman, 2nd edition, 1990.
4. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006.
5. J. G. Speight, The chemisty & Technology of Petroleum, 4th edition, CRC Press, 2006.
6. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009.
7. J.G. Speight and B. Ozum, Petroleum Refining Process, CRC Press, 2009.
8. W. Lyons, Working Guide to Petroleum and Natural Gas Production Engineering, Elsevier Inc, 2009.
9. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons, 2010.
10. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013.
11. J. G. Speight, The Chemistry and Technology of Coal, CRC Press, 2013.

Astrophysics of Stars

Scheme Version: 2021-26	Name of the subject: Astrophysics of Stars	L	T	P	C	Semester: VII	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS PHY 03 703 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Introduction to Astronomy and Astrophysics**		
Course Description	Aim of the Course : Stars are the fundamental building blocks of the Universe. By injecting vast amounts of energy and momentum into their surround-ings, they act as drivers for the evolution of their host galaxies..						
Course Objectives	Aim of this course is to understand in detail what goes on deep inside an object that, to us, is a mere pinprick of light in the sky.						
Course Outcomes	On completion of the course, student would be able to ● Quantify the basic parameters of stars. ● Understand how radiation interacts with matter at the surfaces of stars ● Understand how to produce the spectra that we observe ● Know about the processes that determine the interior structure, composition and evolution of stars.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Stellar Observations:** Introduction, Distance & magnitude, Blackbody radiation, Colors & line spectra, Binary systems: visual binaries, Eclipsing & spectroscopic binaries, The Hertzsprung-Russel diagram, Spectral classification	15
2	**Stellar Atmospheres:** Stellar atmospheres, Describing radiation, Radiation & matter , Radiative transfer, The Eddington approximation, The grey atmosphere, Realistic model atmospheres, Opacity sources, Spectral features, Profile shapes, Line strengths	15
3	**Stellar Interiors:** Mechanical structure, The virial theorem, Polytropes, Equation of state, Energy conservation; diffusive transport, Mass-luminosity relation; main sequences, Convective transport, Energy generation, Nuclear fusion networks, Fusion rates, Rotation, Stellar model building	15

4	**Stellar Evolution:** The main sequence, The Sun, Massive stars, Star formation, Pre-main-sequence evolution, Evolution off the main sequence, Helium burning & beyond, Stellar death, Stellar pulsation, White dwarfs, Neutron stars	15
Text Books		
1. “An Introduction to Modern Stellar Astrophysics”, Bradley W Carroll and Dale A Ostlie (ISBN: 978-08053034830), Cambridge University Press (2017) 2. “Stellar Structure and Evolution”, R. Kippenhahn & A. Weiger, (2012) Springer-Verlag Berlin Heidelberg 3. Structure and Evolution of the Stars, by M. Schwarzschild. (ISBN : 9780691652832), 2016, Princeton University Press 4. Stellar Atmospheres, by Ivan Hubeny , Springer Verlag 5. Radiative Processes in Astrophysics : G. Rybiki and A. Lightmann, 2004 WILEY‐VCH Verlag GmbH & Co.		

Digital Electronics and Microprocessor

Scheme Version:	**Name of the subject:**	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
2021-26	Digital Electronics and Microprocessor	4	0	0	4	VIII	**Total Hours:** 60
Subject Code: SBS PHY 03 801 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		

Course Description	This course covers the topics of Microprocessors, Assembly language, interfacing data converters and peripheral devices, and microcontrollers.
Course Objective	The objective of the course on Semiconductor Devices is to introduce semiconductor physics, physical principle of devices and their basic applications.
Course Outcomes	On completion of the course, student would be able: ● To understand the basic properties of microprocessors and Assembly language. ● To understand basic properties of interfacing data converters and interfacing peripheral devices. ● To understand the working, design and applications of microcontrollers.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Microprocessor:** Buffer registers, Bus oraganised computers, SAP-I, Microprocessor (P) 8085 Architecture, memory interfacing, interfacing I/O devices. Assembly language programming : Instruction classification, addressing modes, timing diagram, Data transfer, Logic and Branch operations-Programming examples.	**15**

2	**Programming techniques** for 8085 microprocessor, Counters and timer delays, Stack and subroutines, Code conversion, BCD, Arithmetic and 16-bit Data operations, Interrupts of 8085, Vectored and nonvectored, maskable and nonmaskable interrupts. **Interfacing data converters** – A/D and D/A, Programmable interface devices – 8255A programmable interface, Interfacing keyboard/Display and Seven-segment display	**15**
3	**Interfacing Programmable Peripheral Devices** – interfacing keyboard and seven segment display, 8254 programmable interval timer, 8259A programmable interval timer, 8259 Programmable Interrupt Controller. Serial communications, Software controlled Asynchronous Serial I/O, Programmable communications interface 8251, RS232	**15**
4	**Microcontrollers** - Overview of the 8051 family, Architecture of 8051, Timers, Interrupts and serial communication in 8051, 8051 programming in C, 8051 timer programming in C, Serial port programming, Interrupts programming.	15

TEXT BOOKS

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085, (Prentice Hall) 2002.
2. Badri Ram, Advanced Microprocessors and Interfacing, (Tata McGraw Hill), 2001.
3. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware (Tata McGraw Hill) 2005.
4. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M. Mckinley (Pearson Education) 2009.
5. The 8051 Microcontroller – I. Scott Mackenzie, R. Chung Wei Phan (Dorling Kindersley (India)), 4th ed. 2007.
6. Microcontrollers - A.J. Ayala, (Penram International), 2nd ed. 1996.
7. Microcontrollers : Arch., Programming, Interfacing & System design, Rajkamal, (Dorling Kindersley (India)), 2009.
8. Microcontroller (Theory & Applications), Ajay V Deshmukh (Tata McGraw Hill) 2012.
9. Embedded System Design, Rajeshwar Singh (Dhanpat Rai), 2nd Ed. 2009.

Solar Energy and Physics of Photovoltaics

<table>
<tr><td rowspan="2">Scheme Version:
2021-2022</td><td rowspan="2">Name of the Subject:
Solar Energy and Physics of Photovoltaics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VIII</td><td>Contact hours per week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 802 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of course: There is no prerequisite or corequisite for this course. But students are expected to know basic semiconductor physics.</td></tr>
<tr><td>Course Description</td><td colspan="7">The course is intended for students who have interest in alternate energy sources as a contributor to sustainability. It provides a comprehensive treatise on the science and technology of solar energy, its collection and the design principles that need to be understood for its effective use in a variety of installations and uses.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● The Course will be introducing the students to all the aspects of PV technology.
● To develop basic understanding related to fabrication and characterization of different types of solar cells.
● To know state of art in the field of solar cells materials and solar cells.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:
● The available solar energy and the current solar energy conversion and utilization processes, solar spectrum.
● The factors that influence the use of solar radiation as an energy source.
● The various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.
● How solar cells convert light into electricity, how solar cells are manufactured, how solar cells are evaluated.</td></tr>
</table>

	• What technologies are currently on the market, and how to evaluate the risk and potential of existing and emerging solar cell technologies. • To examine the potential & drawbacks of currently manufactured technologies, as well as pre-commercial technologies. How to enhance solar cell performance and reduce cost, and the major hurdles-technological and economic, towards widespread adoption.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**Solar Radiation:** origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, sun tracking systems, photo thermal conversion, solar energy collectors, collector efficiency and its dependence on various parameters.	15
2.	**Solar energy:** storage of solar energy, solar pond, solar water heater, solar distillation, solar cooker, solar green houses, solar dryers, absorption air conditioning. solar fuels: electrolysis of water, photoelectrochemical splitting of water.	15
3.	**Fundamentals of solar cells:** Photovoltaic effect, semiconductor properties, energy levels, basic equations, p-n junction its characteristics, fabrication steps, thermal equilibrium condition, depletion capacitance, junction breakdown, heterojunction. Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells.	15
4.	**Device physics**: Solar cell device structures, construction, output power, efficiency, fill factor and optimization for maximum power, surface structures for maximum light absorption, current voltage characteristics in dark and light, operating temperature vs conversion efficiency, charge carrier generation, recombination and other losses. Cadmium telluride solar cells, copper indium gallium selenide solar cells, organic solar cells, perovskite solar cells, Advanced concepts in photovoltaic research.	15

REFERENCE BOOKS
1. S P Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 1996. 2. Solid State Electronic Devices, Ben. G. Streetman, S. K. Banerjee, PHI Leaning Pvt. Ltd, 2000. 3. D. Yogi Goswami, Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, Taylor and Francis, 2000. 4. Jasprit Singh, Semiconductor Devices, Basic Principles, Wiley, 2001 5. Stephen J.Fonash, Solar Cell Device Physics, 2nd edition, Academic Press, 2003. 6. H P Garg, J Prakash, Solar energy fundamentals and applications, Tata McGraw Hill publishing Co. Ltd, 2006.

General Theory of Relativity

Scheme Version: 2021-26	Name of the subject: General Theory of Relativity	L	T	P	C	Semester: VIII	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS PHY 03 803 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite:** Classical Electrodynamics, Mathematical Physics-I, II, III		
Course Description	This course on General Theory of Relativity covers topics of Special Theory of Relativity, General Theory of Relativity and its applications.						
Course Objectives	The objective of the course is to familiarize students with different aspects of theory of gravitation.						
Course Outcomes	On completion of the course, student would be able to ● **U**nderstand the mathematical rigour that goes behind the theory of relativity and also be able to ● Understand few applications of general theory of relativity. ● Understand the Special theory of relativity ● Understand the origin of gravitational waves						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Historical Background** : Review of Newtonian Mechanics. Special theory of relativity. Prelude to General relativity, historical developments, 4-Vectors and 4-tensors, examples from physics	15
2	**Tensors in GTR**: Principle of Equivalence, Equations of motion, Gravitational force, Tensor Analysis in Riemannian space, Effects of Gravitation, Riemann-Christoffel curvature tensor, Ricci Tensor, Curvature Scalar	15

3	**Applications of GTR:** Einstein Field Equations, Experimental tests of General Theory of Relativity, Scwartzchild Solution, Gravitational lensing	15
4	**Gravitational Radiation:** Gravitational waves: generation and detection, Energy, momentum and angular momentum in Gravitation	15

Text Books

1. S. Weinberg, Cosmology, Oxford University, 1st Ed., 2008.
2. Ray D'Inverno, Introducing Einstein's General Relativity, Oxford University, 1st Ed., 1992.
3. M. Berry, Principle of Cosmology and Gravitation, Taylor & Francis; 1st Ed., 1989.
4. Tai L. Chow, Introduction to General theory of Relativity and Cosmology, Springer, 1st Ed., 2008.
5. P.A.M. Dirac, General theory of Relativity, Wiley-Blackwell, 1st Ed., 1975.
6. L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Publishere, Shroff, 2nd Ed., 2010

Accelerator Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Accelerator Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 804 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Nuclear Physics, Electrodynamics, Quantum mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to expose the students to theoretical design and usage of various particle accelerators.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the beam optics.
● Get knowledge about different types of accelerators
● To understand the main features of superconducting cyclotron, linear accelerators and high energy accelerators.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the beam optics & beam transport system.
● Learn about various theoretical techniques to accelerate particles and technical details of electrostatic accelerators.
● Get knowledge about latest accelerator technology based on Rf cavities.
● Learn about Synchrotron Radiations & production of radioactive ion beams.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Charged Particle Dynamics:** Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.	15
2	**Electrostatic and Heavy Ion Accelerators:** Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams.	15
3	**Radiofrequency Accelerators:** Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs, Superconducting Heavy Ion Linear Accelerators. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.	15
4	**Synchrotron Radiation Sources:** Electromagnetic radiation from relativistic electron beams, Electron synchrotron, Characteristics of synchrotron radiation. Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators.	15

TEXT BOOKS

1. M.S. Livingston and J.P. Blewel, Particle Accelerators, McGraw-Hill Book Press, 1962.
2. Ed. J. Cerny, Nuclear Spectroscopy and Reactions Part-A, Academic Press, 1974.
3. H.J. Wiedman, Particle Accelerator Physics, Vol I and II, Springer Verlag, 1998.
4. S. Y. Lee, Accelerator Physics, World Scientific, Singapore, 2004

Characterization Techniques for Materials

<table>
<tr><td rowspan="2">Scheme Version:
2021-26</td><td rowspan="2">Name of the subject:
Characterization Techniques for Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 805 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course covers the fundamental principles and practical applications of different classes of materials and characterization techniques. The course discusses characterization techniques used for chemical and structural analysis of materials, including metals, ceramics, polymers, composites, and semiconductors. The topics include important spectroscopic, microscopic and thermal methods for materials characterization.</td></tr>
<tr><td>Course Objective</td><td colspan="7">● To introduce the materials characterization techniques to the students
● Help the students to understand the instrumentation aspects
● To provide a detailed understanding of data interpretation
● To provide hands on experience of the characterization techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
● To determine crystal structure of specimen and estimate its crystallite size and stress
● To choose an appropriate microscopy techniques to investigate microstructure of materials at high resolution
● To use appropriate spectroscopic technique to measure vibrational/electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
● To apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Structure analysis:** X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Phase identification, indexing and lattice parameter determination, Powder X-ray diffractometer. Applications of XRD in bulk and nano-materials.	15
2	**Microscopy techniques: I**ntroduction to Microscopes, Optical microscopy, Transmission Electron Microscopy (TEM); Basic Electron scattering, Concepts of resolution, TEM instruments, Various imaging modes, Analysis of micrographs, Electron Energy Loss Spectroscopy, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (AFM and STM)	15
3	**Spectrophotometric analysis of materials:** UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron Spectroscopy (XPS).	15
4	**Thermal analysis techniques:** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA) **Electrical characterization techniques:** Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance	15

TEXT BOOKS

1. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, 1986.
2. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth Heinemann, 1993.
3. Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, 2000.
4. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction”, Prentice-Hall, 2001.
5. B. Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-Destructive Testing, 2nd ed., Narosa Publishing House, 2002.
6. D. A. Skoog, F.J. Holler, S. R. Crouch, Instrumental Analysis, Cengage Learning, 2007.
7. Li Lin, Ashok Kumar, Materials Characterization Techniques Sam Zhang; CRC Press, 2008.
8. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
9. J. C. Vickerman, I. Gilmore, Surface Analysis: The Principal Techniques, 2 nd ed., John Wiley & Sons, Inc.2009.

Cosmology

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject: Cosmology</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 901 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Introduction to Astronomy and Astrophysics</td></tr>
<tr><td>Course Description</td><td colspan="7">Cosmology is a branch of astronomy that involves the origin and evolution of the universe, from the Big Bang to today and on into the future.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The aim of this course is to introduce the model of the universe on large scales</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to
● Understand the concepts of STR and GTR
● Apply the concepts of GTR to cosmology
● Understand the model of expanding universe
● Explain the model of early universe and its thermal history.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Principles of Relativity: Overview of Special Relativity - spacetime interval and Lorentz metric- four vectors - Introduction to general relativity (GR) - equivalence principle - notions of curvature</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Gravitation as a manifestation of the curvature of spacetime: Gravitational redshift and clock corrections - orbits in strong gravity, light bending and gravitational lensing - concept of horizon and ergosphere, hydrostatic equilibrium in GR - gravitational radiation.</td><td>15</td></tr>
<tr><td>3</td><td colspan="6">Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder –Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble’s law - Robertson-</td><td>15</td></tr>
</table>

	Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman-Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes.	
4	**Physical Cosmology and Early Universe:** Thermal History of the Universe - distribution functions in the early Universe – relativistic and nonrelativistic limits - Decoupling of neutrinos and the relic neutrino background - Nucleosynthesis - Decoupling of matter and radiation – Cosmic microwave background radiation (CMB)-Anisotropies in CMB - Inflation – Origin and growth of Density Perturbations - Formation of galaxies and large scale structures - Accelerating universe and type-Ia supernovae - The Intergalactic medium and reionization.	15

Text Books

1. Cosmological Physics, Cambridge University Press, J . A. Peacock
2. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010
3. Theoretical Astrophysics, Volume III: Galaxies and Cosmology,
T. Padmanabhan,Cambridge University Press, 2002 (for lectures on Cosmology)
4. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994 (For more material on General Relativity).
5. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology).
6. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity).
7. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995 (for material on Cosmology and Structure formation).

Plasma Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Plasma Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 902 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Mathematical Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">Students will be exposed to theory related to motion of charge particle in an inhomogeneous field, production of plasma and usage of plasma.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To make students familiar with fourth state of matter
● To aware students about plasma creation in laboratory
● To make students familiar with production of energy in fusion reactor</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will have understanding of
● what are theoretical method to study the charge particle motion
● Idea behind the magnetic confinement
● how to generate plasma in the laboratory
● how plasma production is helpful to make fusion reactors</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Introduction: Plasma state, plasma parameters, applications of plasmas.</td><td>15</td></tr>
</table>

	Single particle orbit theory: Drift of charge particle under different combinations of electric and magnetic field, crossed electric and magnetic fields, homogenous electric and magnetic fields, spatially and time varying electric and magnetic fields,	
2	**The Boltzmann Equation:** Simplified magneto-hydrodynamic equations - Electron plasma oscillations Debye shielding phenomenon and criteria for plasma, motion of charged particles in electromagnetic field, Electric field drift, parallel acceleration, curvature drift, adiabatic invariants; fundamental equations of magneto-hydrodynamics(MHD), magnetic confinement.	15
3	**Production of Plasma in laboratory:** Physics of glow discharge, electron emission, ionization breakdown of gasses, Paschen's law and different regimes of E/ρ in a discharge. **Plasma diagnostic:** Probes, energy analysers, magnetic probes and optical diagnostics, preliminary concepts.	15
4	**Fusion Reactor**: Potential of fusion energy, controlled thermonuclear reactions, fusion reactions, fusion cross-sections, fusion power generation, energy balance for fusion systems, ignition criterion, gain factor, plasma heating, ohmic heating, neutral beam injection, radio frequency heating, inertial confinement fusion, tokamaks, stability, operating limits and transport.	15

TEXT BOOKS

1. Nicholson, D. R., Introduction to Plasma theory, Wiley, 1983
2. Chen, F.F., Introduction to Plasma Physics, Springer, 1984
3. Sturrock, P.A., Plasma Astrophysics, Cambridge University Press, 1994
4. Choudhuri, A.R., The Physics of Fluids and Plasmas, Cambridge University Press, 1998

Experimental Techniques in Nuclear and Particle Physics

Scheme Version:	**Name of the subject:**	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
2021-26	Experimental Techniques in Nuclear and Particle Physics	4	0	0	4	IX	**Total Hours:** 60

Subject Code:	**Applicable to Programs:**	**Evaluation (Total Marks: 100)**			
SBS PHY 03 903 DS 4004	Integrated B.Sc. M.Sc. (Physics)		**CIE**	30 Marks	**Examination Duration:** 3 hours
			TEE	70 Marks	**Prerequisite of Course:** Basics of Nuclear Physics and Particle Physics

Course Description	This course is intended to familiarize the M.Sc. students to the experimental techniques used in the fields of nuclear physics and particle physics. Various detection techniques will be introduced followed by a description of on-detector and off-detector electronics.
Course Objectives	● Get knowledge about various experimental techniques used in the fields of nuclear physics and particle physics. ● To get familiar with various detector systems and related electronics.
Course Outcomes	After completion of this course, students would be able to: ● Get knowledge about different types of radiations & their interaction with matter. ● Understand the radiation exposure and its effects on the biological system. ● Learn about how to detect radiations. ● Get knowledge about the various electronic components of radiation detectors and pulse signal processing. ● Understand Learn about different existing detector facilities all around the world.

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**

1	**Radiation interactions:** Nuclear processes in radioactive sources: types of radiations & radiation sources; Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. Radiation protection, Biological effects of radiation, radiation monitoring.	15
2	**Detection of radiations:** General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Gas-filled detectors: Ionization chamber, Proportional counters, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Scintillation detector, Phoswich detectors, Cherenkov detector. Semiconductor detectors. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding.	15
3	**Detector electronics:** Electronics for pulse signal processing, $CR-(RC)^n$ and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers, overload recovery and pileup, Linear amplifiers, single-channel analyser, analog-to-digital converters, multichannel analyzer. Basic considerations in time measurements; Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.	15
4	**Experimental Facilities:** Detector systems for heavy-ion reactions: Large neutron detector array, gamma and charge particle detector arrays, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments**:** basics of Collider physics, Modern Hybrid experiments- CMS and ALICE.	15

TEXT BOOKS

1. W.R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer, Berlin Heidelberg, 2nd Edition, 1994.
2. Konrad Kleinknecht, Detectors for particle radiation, Cambridge University Press, 1999.
3. Richard Fernow, Introduction to Experimental Particle Physics, Cambridge University Press, 2001.
4. Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 4th Edition, 2010.

Reactor Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:
Reactor Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 904 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks :100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to impart primary but wide theoretical knowledge about nuclear reactors and related topics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the theoretical and experimental knowledge about nuclear reactors.
● To know about the basic designs of nuclear reactors.
● To understand the need of nuclear fuel and waste management.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the nuclear fission reactions.
● Learn about neutron sources and moderators.
● Get knowledge about working of nuclear reactors.
● Get knowledge about different types of power reactors
● Learn how to manage the nuclear fuel and waste.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Nuclear Reactions: Characteristics of atomic nucleus, Binding energy, Nuclear fission, Cross section, Interaction of neutrons with nuclei.</td><td>15</td></tr>
</table>

2	**Neutron moderation**: Inelastic scattering, Elastic collisions, Moderating ratio, Slowing down Density, Resonance escape, Moderators, Neutron sources, Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.	15
3	**Nuclear Reactors:** Fuel materials, Moderator materials, Cladding materials, Coolant materials and control materials, Control requirement calculations, Means of control, Reactor kinematics: Neutron lifetime, Generation time, Point kinetic equation and solution of the equations for step input reactivity.	15
4	**Types of Power reactors & Fuel and waste management:** Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.	15

Laboratory Assignments:

Visits to fission reactor sites and related case studies for generation of nuclear energy.

TEXT BOOKS

1. Lamarshs, J.R., Introduction to Nuclear Reactor Theory, Addison-Wesley Publishing Co., 1966.
2. Glasstons, S. and Sesonske, A., Nuclear reactor Engineer, CBS Publishers & Distributors, 1986.

Advanced Carbon Materials

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject: Advanced Carbon Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 905 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce students to the advanced carbon material that includes graphene, fullerenes, hierarchical carbon, and CNTs are referred to as the strength of revolution and advancement in the era of material science and technology. In general, the 20th century corresponds to plastic, while the 21st century will be named as “Century of Graphene” owing to its exceptional physical properties.</td></tr>
<tr><td>Course Objective</td><td colspan="7">On completion of the course, student would be able:
To understand various properties of Graphene, CNTs and Fullerenes</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
To understand the basic properties of carbon
To understand the various properties and applications of graphene
To understand the various properties and applications of CNT
To understand the various properties and applications of fullerenes</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction:** Carbon atomic structure and hybridization, carbon on the Earth and in outer space, carbon in technology and economy, carbon isotopes: classification of carbon allotropes, conversion of	**15**

	one allotropic form into another, phase diagram of carbon, new carbon structures: discovery of C_{60}, Graphene and Nanotubes	
2	**Graphene:** Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties – Band Structure of Graphene - Mobility and Density of Carriers - Quantum Hall Effect – Characterization of graphene: Raman Spectroscopy, Infrared Spectroscopy, Absorption and Photoluminescence Spectroscopy, Atomic Force Microscopy, Application of graphene	**15**
3	**Carbon Nanotubes:** The Structure of Carbon Nanotubes-Nomenclature, Structure of Single-Walled Carbon Nanotubes and Structure of Multiwalled Carbon Nanotubes; Synthesis of CNT by various physical and chemical methods and Purification, Characterization of Carbon Nanotubes: Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes. Application of CNTs	**15**
4	**Fullerenes**: Structure and Bonding- Nomenclature, The Structure of C60, Structure of Higher Fullerenes - Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties-, Spectroscopic Properties, Thermodynamic Properties; Chemical Properties- Hydrogenation and Halogenation, Nucleophilic Addition to Fullerenes. Application of Fullerenes	**15**

TEXT BOOKS

1. M.S. Dresselhaus, G. Dresselhaus and P.C. Eklund, Science of Fullerenes and Carbon Nanotubes, Elsevier, 1996.
2. Yury Gogotsi, Carbon Nanomaterials, Taylor and Francis, 2006.
3. Francois Leonard, The Physics of Carbon Nanotube Devices, Elsevier, 2008.
4. Anke Krueger, Carbon Materials and Nanotechnology, Wiley-VCH, 2010.
5. D.R. Askeland, P.P. Phule, W.J. Wright, The Science and Engineering of Materials, 6th ed., Cengage Learning, 2010.
6. Jamie H. Warner, Franziska Schäffel, Mark H. Rümmeli, Graphene: Fundamentals and emergent applications, Elsevier, 2013.
7. T. Pradeep, NANO: The Essentials- Understanding Nanoscience and Nanotechnology, McGraw Hill Education, 2017.
8. Deborah D L Chung, Carbon Materials: Science and Applications, World Sci., 2019.

8. Teaching-Learning Process

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

9. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasises student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimises and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, be adopted.

Note: MOOC courses (SWAYAM) having similarity more than 75% with the core courses may be offered to the students. For SEC/GEC/AECC/DSEC courses, the students may opt from the MOOC courses provided these courses are not in the list of core courses and students have not studied similar courses earlier. Since, the list of MOOC courses keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

10. Assessment and Evaluation

- The question paper for End Semester examination may contain up to 40% of numericals.
- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

11. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Graduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

12. References

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf
- Learning Outcomes based Curriculum Framework (LOCF) for Undergraduate Programme B.Sc. (Physics) 2019 https://www.ugc.ac.in/pdfnews/1884134_LOCF-Final_Physics-report.pdf

Annexure-VI

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi

of

Integrated B.Sc.-M.Sc. (Physics)

Session: 2022-27

DEPARTMENT OF PHYSICS & ASTROPHYSICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	Approved	Approved	
Approval Date :	08.08.2022	12.09.2022	

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VISION AND MISSION

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through the promotion of innovation, creative endeavors, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for the creation of a knowledge community, by building a strong character and nurturing value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research, and innovation in pure and applied areas of learning.

Vision and Mission of the Department of Physics and Astrophysics

Vision

To establish a platform for the dissemination and creation of knowledge through teaching and research in Physics and Astrophysics at various levels. To help create a scientific society that encourages logical thinking.

Mission

- To offer a state of art Academic Programs in Physics and interdisciplinary areas.
- To create an intellectual property through innovations, quality research publications, and patents
- To create state of art research laboratories that will facilitate the research of the Central University of Haryana as well as other academic institutions.

1. Background

i. NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of the Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programs in alignment with the National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted by the adoption of the "Comprehensive Roadmap for Implementation of NEP-2020" in the 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and an indicative timeline for major academic reforms.

The process of revamping the curriculum started with a series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st-century skills for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In the case of UG programs in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council, and other relevant agencies/sources. The University has also developed a consensus on the adoption of Blended Learning with 40% component of online teaching and 60% face-to-face classes for each program.

The revised curricula of various programs could be devised with concerted efforts of the faculty, Heads of the Departments, and the Deans of Schools of Study. The draft prepared by each department was discussed in a series of discussion sessions conducted at the Department, School, and University levels. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice-Chancellor of the University conducted a series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate and Graduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References, and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each program.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii. About the Subject

Physics is the natural science that studies matter, its motion and behavior through space and time, and the related entities of energy and force. Physics is one of the most fundamental scientific disciplines and its main goal is to understand the behavior of the universe and its characteristics.

Physics uses the scientific method to help uncover the basic principles governing light and matter, and to discover the implications of those laws. It assumes that there are rules by which the universe functions, and that those laws can be at least partially understood by humans. It is also commonly believed that those laws could be used to predict everything about the universe's future if complete information was available about the present state of all light and matter.

With the inclusion of Astronomy, Physics became one of the oldest academic disciplines. Physics intersects with many interdisciplinary areas of research. New ideas in physics often explain the fundamental mechanisms studied by other branches of science and suggest new avenues of research in academic disciplines such as mathematics, etc. Advancement in Physics often leads to new technologies.

iii. About the Programme (Nature, extent, and aims)

Integrated B.Sc.-M.Sc. (Physics) is a five-year regular program. There are ten semesters in this program. The duration of each semester is sixteen weeks. Teaching and learning process of Integrated B.Sc.-M.Sc. (Physics) involves theory and practical classes along with seminar presentations and research project work.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools, and other teaching aids that can be used as and when required. Emphasis will be given to laboratory work and visiting National laboratories to give hands-on experience to students. Students will be encouraged to do semester-long projects in their own institutes as well as in reputed institutes at the National level. The aims of the Programme are as follows:

- Understand the underlying Physics in respective specializations, and, be able to teach and guide successfully
- Introduce advanced ideas and techniques that are applicable in respective fields.
- Provide the students with a broad spectrum of Physics Courses
- Emphasize the role of Physics in other disciplines such as (Chemical Sciences, Mathematical Sciences, Life Sciences, and their applied areas)
- Develop the ability of the students to observe, perform, analyze and report an experiment
- Develop the ability of the students to deal with physical models and formulas mathematically
- Equip the students with different practical, intellectual and transferable skills.

- Strengthen the student's knowledge of physics and its applications in the real world.
- Provide the student with mathematical and computational tools and models to be used in solving professional problems
- Improve the inter-disciplinary skills of the students.
- To develop human resources with a solid foundation in theoretical and experimental aspects of respective specializations as a preparation for a career in academia and industry.

iv. Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a degree/diploma/certificate based on the credits acquired. The students will have an option to choose different paths seeking a sphere of knowledge and domain of professional work that can fulfill their dreams. The students will be able to demonstrate their knowledge in advanced branches of Physics. This will establish a platform over which students can pursue higher studies. The possible career paths are:

- Teaching Assignments
- Scientific Assignments
- Instruments development
- Research and Development in Industries
- Simulation Techniques Development in Science
- Role in Renewable Energy Resources
- University/Institute Administrative Assignments
- Technician in Lasers, Accelerators, Detectors, and Electronics
- Astronomer
- Medical Device Designer
- Radiologist

2. Programme Outcomes (POs)

Students enrolled in the Integrated B.Sc.-M.Sc. (Physics) offered by the Department of Physics and Astrophysics under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attaining important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the program.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the program.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate, and analyze scientific problems and innovatively designing and creating products and solutions to real-life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution to burning research problems in the concerned and associated fields at the global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for the betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate to social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish an independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The students shall be able to realize the following specific outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	Identify, formulate, and solve Physics problems
PSO-2	Design and conduct experiments, as well as analyze and interpret data
PSO-3	Apply knowledge of Physics in a different stream of science and to communicate effectively.
PSO-4	Ability to use the techniques, skills, and modern physical tools in a real-world application.
PSO-5	Engage in life-long learning and will have recognition.

4. Graduate Attributes

Some of the characteristic attributes of a graduate in Physics are:

- **Disciplinary knowledge and skills: Capable of demonstrating**
    a. good knowledge and understanding of major concepts, theoretical principles and experimental findings in Physics and its different subfields like Astrophysics and Cosmology, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and other related fields of study, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology, etc.
    b. ability to use modern instrumentation and laboratory techniques to design and perform experiments is highly desirable in almost all the fields of Physics listed above in (a).
- **Skilled communicator:** Ability to transmit complex technical information relating to all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem-solving skills in all the basic areas of Physics.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics, and planning, executing, and reporting the results of a theoretical or experimental investigation.
- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop, and in industry and field-based situations.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.
- **Digitally Efficient:** Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data, and employing modern e-library search tools like Inflibnet, various websites of the renowned Physics labs in countries like the USA, Europe, Japan, etc. to locate, retrieve, and evaluate Physics information.

- **Ethical awareness/reasoning:** The graduate should be capable of demonstrating the ability to think and analyze rationally with a modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.
- **National and international perspective:** The graduates should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing toward the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

5. Structure of Integrated B.Sc.-M.Sc. Course

Semester	Core Courses (CC) each with 06 credits (All courses are compulsory)	Generic Elective (GE) each with 06 credits (to be opted from given list of courses)	Skill Enhancement Course (SEC) each with 02 credits (to be opted from given list of courses)	Discipline Specific Elective (DSE) each with 06/04 credits (to be opted from given list of courses)	Ability Enhancement Compulsory Courses (AECC) (to be opted from given list of courses)	Total Credits
I	CC-01 CC-02	GE-01			AECC-01	22
II	CC-03 CC-04	GE-02			AECC-02	22
III	CC-05 CC-06 CC-07	GE-03	SEC-01			26
IV	CC-08 CC-09 CC-10	GE-04	SEC-02			26
V	CC-11 CC-12		SEC-03	DSE-01 DSE-02		26
VI	CC-13 CC-14		SEC-04	DSE-03 DSE-04		26
VII	CC-15* CC-16* CC-17* CC-18	GE-05*		DSE-05*		26
VIII	CC-19* CC-20* CC-21* CC-22			DSE-06* DSE-07*		26
IX	CC-23* CC-24* CC-25 CC-26			DSE-08* DSE-09*		28
X	CC-27**					20
TOTAL CREDITS						**248**

***4 credits** ****20 credits**

Total Credits of the Course: 248

Types of Courses	Nature	Total Credits	%
Compulsory Courses	Core Courses (CC)	160	64.5%
	Ability Enhancement Compulsory Courses (AECC)	08	3.2%
Elective Courses	Discipline Specific Elective Courses (DSE)	44	17.8%
	Generic Elective Courses (GE)	28	11.3%
	Skill Enhancement Courses Elective Courses (SEC)	08	3.2%

Exit Options: As per appropriate ordinance

6. Learning Outcome Index

Core Course for B.Sc (Hons.)

S. No.		CC-I	CC-II	CC-III	CC-IV	CC-V	CC-VI	CC-VII	CC-VIII	CC-IX	CC-X	CC-XI	CC-XII	CC-XIII	CC-XIV
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basic Physics concepts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with related disciplines	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related field of specialization	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to use in Physics problem	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X	X	_	_	X	_	_	X	X	X	X
8	Skills in performing analysis and interpretation of data	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Develop investigative Skills	X	X	X	X	X	X	X	X	_	X	X	X	X	X
10	Skills in problem solving in Physics and related discipline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop Technical Communication skills	X	X	X	X	-	-	X	X	X	X	X	X	X	X
12	Developing analytical skills and popular communication	X	X	X	X	-	-	-	-	X	_	_	X	X	X
13	Developing ICT skills	X	X	X	X	X	X	X	X	_	X	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	X	X	X	X	X	X	X	X	X	X	X	X	X	X

7. Semester-wise Courses & Credit Distribution

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
(CHOICE BASED CREDIT SYSTEM)

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Semester I

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics-I	SBS PHY 03 101 CC 4004	4	0	0	4
2	Mechanics	SBS PHY 03 102 CC 4004	4	0	0	4
3	Ability Enhancement Compulsory Course (AECC-01)		4	0	0	4
4	Skill Enhancement Course (SEC-02)		2/0	0	0/4	2
5	Generic Elective Course (GE-01)		4/5	0/1	4/0	6
6	Physics Laboratory-I	SBS PHY 03 103 CC 0042	0	0	4	2
7	Introduction to Computer Programming	SBS PHY 03 104 CC 0042	0	0	4	2

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The AECC course of "Environmental Studies [SBS EVS 0107 AECC 4004]" will be offered in one of the first two semesters as a compulsory course and the student will opt for a course based on Modern Indian Language (MIL) communications in the other semester:
    - English Communications [SBS ENG 0207 AECC 4004]
    - प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1) [SBS SKT 0209 AECC 4004]
    - हिंदी भाषा: रचना एवं व्यवहार [SBS HIN 0208 AECC 4004]

- The Department offers Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

SEC-01
- Physics Workshop Skills [SBS PHY 03 101 SE 0042]
- Renewable Energy and Energy Harvesting [SBS PHY 03 102 SE 200

Semester II

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Electricity and Magnetism	SBS PHY 03 201 CC 4004	4	0	0	4
2	Waves and Optics	SBS PHY 03 202 CC 4004	4	0	0	4
3	Ability Enhancement Compulsory Course (AECC-02)		4	0	0	4
4	Skill Enhancement Course (SEC-02)		2/0	0	0/4	2
5	Generic Elective Course (GE-02)		4/5	0/1	4/0	6
6	Physics Laboratory-II	SBS PHY 03 203 CC 0042	0	0	8	4

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    2. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The AECC course of "Environmental Studies [SBS EVS 0107 AECC 4004]" will be offered in one of the first two semesters as a compulsory course and the student will opt for a course based on Modern Indian Language (MIL) communications in the other semester:
    - English Communications [SBS ENG 0207 AECC 4004]
    - प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1) [SBS SKT 0209 AECC 4004]
    - हिंदी भाषा: रचना एवं व्यवहार [SBS HIN 0208 AECC 4004]

- The Department offers Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

SEC-02
- Computational Physics Skills [SBS PHY 03 201 SE 0042]
- Applied Optics [SBS PHY 03 202 SE 0042]

Semester III

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics–II	SBS PHY 03 301 CC 4004	4	0	0	4
2	Thermal Physics	SBS PHY 03 302 CC 4004	4	0	0	4
3	Analog Systems and Applications	SBS PHY 03 303 CC 4004	4	0	0	4
4	Physics Laboratory-III	SBS PHY 03 304 CC 00126	0	0	12	6
5	Skill Enhancement Course (SEC-03)		2/0	0	0/4	2
6	Generic Elective Course (GE-03)		4/5	0/1	4/0	6

- The GE courses offered by the Department of Physics and Astrophysics can only be taken by the students of the other Departments. The students of Integrated B.Sc. M.Sc. (Physics) programme will opt the GE courses offered by other departments of the University based on the following disciplines:
    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The Department offers Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

  SEC-03
    - Basic Instrumentation Skills [SBS PHY 03 301 SE 0042]
    - Weather Forecasting [SBS PHY 03 302 SE 2002]

Semester IV

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Mathematical Physics-III	SBS PHY 03 401 CC 4004	4	0	0	4
2	Elements of Modern Physics	SBS PHY 03 402 CC 4004	4	0	0	4
3	Digital Systems and Applications	SBS PHY 03 403 CC 4004	4	0	0	4
4	Physics Laboratory-IV	SBS PHY 03 404 CC 00126	0	0	12	6
5	Skill Enhancement Course (SEC-04)		2/0	0	0/4	2
6	Generic Elective Course (GE-04)		4/5	0/1	4/0	6

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    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The Department offers Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

  SEC-04
    - Electrical Circuit and Network Skills [SBS PHY 03 401 SE 2002]
    - Radiation Safety [SBS PHY 03 402 SE 2002]
    - Physics for Fun [SBS PHY 03 403 SE 0042]

Semester V

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Quantum Mechanics and Applications	SBS PHY 03 501 CC 4004	4	0	0	4
2	Solid State Physics	SBS PHY 03 502 CC 4004	4	0	0	4
3	Physics Laboratory-V	SBS PHY 03 503 CC 0084	0	0	8	4
4	Discipline Specific Elective Course (DSE-01)		4/5	0/1	4/0	6
5	Discipline Specific Elective Course (DSE-02)		4/5	0/1	4/0	6

- The Department offers discipline-specific elective (DSE) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-01
1. Experimental Techniques [SBS PHY 03 501 DS 5106]
2. Biophysics [SBS PHY 03 502 DS 5106]
3. Earth Sciences [SBS PHY 03 503 DS 5106]

DSE-02
1. Nuclear and Particle Physics [SBS PHY 03 504 DS 5106]
2. Atmospheric Physics [SBS PHY 03 505DS 5106]
3. Physics of Devices and Instrumentation [SBS PHY 03 506 DS 5106]

Semester VI

Total credits: 24

S. No.	Course Title	Course Code	L	T	P	Credits
1	Electromagnetic Theory	SBS PHY 03 601 CC 4046	4	0	0	4
2	Statistical Mechanics-I	SBS PHY 03 602 CC 4046	4	0	0	4
3	Physics Laboratory-VI	SBS PHY 03 603 CC 0084	0	0	8	4
4	Discipline Specific Elective Course (DSE-03)		4/5	0/1	4/0	6
5	Discipline Specific Elective Course (DSE-04)		4/5	0/1	4/0	6

The Department offers discipline-specific elective (DSE) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-03
1. Nanomaterials and Applications [SBS PHY 03 601 DS 5106]
2. Medical Physics [SBS PHY 03 602 DS 5106]

DSE-04
1. Astronomy and Astrophysics [SBS PHY 03 603 DS 5106]
2. Embedded systems- Introduction to Microcontroller [SBS PHY 03 604 DS 5106]

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Semester VII

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Classical Mechanics	SBS PHY 03 701 CC 4004	4	0	0	4
2	Advanced Mathematical Physics	SBS PHY 03 702 CC 4004	4	0	0	4
3	Advanced Quantum Mechanics	SBS PHY 03 703 CC 4004	4	0	0	4
4	Physics Laboratory-VII	SBS PHY 03 704 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-05)		4	0	0	4
6	Generic Elective Course (GE-05)		4	0	0	4

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    1. Mathematics 2. Chemistry 3. Computer Science or any other discipline of importance

- The Department offers discipline-specific elective (DSE) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-05

1. Statistical Mechanics-II [SBS PHY 03 701 DS 4004]
2. Introduction to Hydrogen Energy Systems [SBS PHY 03 702 DS 4004]
3. Astrophysics of Stars [SBS PHY 03 703 DS 4004]

Semester VIII

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Classical Electrodynamics	SBS PHY 03 801 CC 4004	4	0	0	4
2	Atomic and Molecular Physics	SBS PHY 03 802 CC 4004	4	0	0	4
3	Nuclear Physics	SBS PHY 03 803 CC 4004	4	0	0	4
4	Physics Laboratory-VIII	SBS PHY 03 804 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-06)		4	0	0	4
6	Discipline Specific Elective Course (DSE-07)		4	0	0	4

- The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-06
1. Digital Electronics and Microprocessor [SBS PHY 03 801 DS 4004]
2. Solar Energy and Physics of Photovoltaic [SBS PHY 03 802 DS 4004]

DSE-07
1. General Theory of Relativity [SBS PHY 03 803 DS 4004]
2. Accelerator Physics [SBS PHY 03 804 DS 4004]
3. Characterization Techniques for Materials [SBS PHY 03 805 DS 4004]

Semester IX

Total credits: 28

S. No.	Course Title	Course Code	L	T	P	Credits
1	Condensed Matter Physics	SBS PHY 03 901 CC 4004	4	0	0	4
2	Particle Physics	SBS PHY 03 902 CC 4004	4	0	0	4
3	Physics Laboratory-IX	SBS PHY 03 903 CC 00126	0	0	12	6
4	Minor Project	SBS PHY 03 904 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-08)		4	0	0	4
6	Discipline Specific Elective Course (DSE-09)		4	0	0	4

The Department offers discipline-specific elective (DSE) courses and Skill-Enhancement Elective (SEC) courses depending on the specialization and strength of faculty members, and the number of students. If class strength is less than 10, then that particular subject will not be offered.

DSE-8

1. Cosmology [SBS PHY 03 901 DS 4004]
2. Plasma Physics [SBS PHY 03 902 DS 4004]

DSE-9

1. Experimental Techniques in Nuclear and Particle Physics [SBS PHY 03 903 DS 4004]
2. Reactor Physics [SBS PHY 03 904 DS 4004]
3. Advanced Carbon Materials [SBS PHY 03 905 DS 4004]

Semester X

Total credits: 20

S. No.	Course Title	Course Code	L	T	P	Credits
1	Dissertation	SBS PHY 03 X01 CC XXX20	-	-	-	20

Note: A continuous monitoring of the work being done will be done by the departmental committee and a minimum of two presentations are to be presented by the student.

Course Contents

(for Semester I to VI)

Core Courses

Mathematical Physics-I

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 101 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basic knowledge of 10+2 standard mathematics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to teach the Calculus, Vector Calculus, Orthogonal Curvilinear Coordinates, Dirac Delta function and its properties and Introductory theory of probability.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The objective of the course is to provide the students training in Calculus to solve various mathematical problems. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
Revise the knowledge of calculus, vectors, vector calculus, probability and probability distributions. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
Learn the Dirac delta function its properties, which have applications in various branches of Physics, especially quantum mechanics.
In the laboratory course, learn the fundamentals of the C and C++ programming languages and their applications in solving simple physical problems involving interpolations, differentiations, integrations, differential equations as well as finding the roots of equations.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Calculus:** Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions, Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.	20
2	**Vector Calculus:** Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).	20
3	**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	8
4	**Introduction to probability:** Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with	12

	examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **Dirac Delta function and its properties:** Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.	

TEXT BOOKS

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Mathematical Physics, Goswami, 1 st edition, Cengage Learning
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.
- Mathematical Physics, H.K. Dass and R. Verma, 2021, S. Chand & Company.

Mechanics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 102 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Knowledge of Vector Algebra & Vector Calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce elementary concepts of Mechanics to the students so that they are able to understand fundamental aspects of forces, nature of forces and their applications. Objective here is that with the comparatively advanced mathematics tools than their high school curriculum, they will be able to apply these concepts in other branches of Physics and Science in general.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of Physics
● To get familiar with various concepts of mechanical problems related to Gravitational Force, spring force and oscillations.
● To inform the students about applications of mechanics in other science branches.
● To have a clear understanding about concepts related to space, time and relative motion.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the fundamentals of dynamics in constant as well as variable mass systems
● Learn about various concepts related to rotational dynamics and elasticity.
● Learn about gravitational force and spring force
● Understand the basic inception of space and time, and relative motion in inertial as well as non-inertial frames.</td></tr>
<tr><td colspan="8"></td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Fundamentals of Dynamics :** Review of vector algebra and differential calculus of vectors: gradient, divergence and curl. Reference frames. Inertial frames; Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as the gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of Conservation of Energy with an example of a spring-mass system.	18
2	**Rotational Dynamics**: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. **Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.	14
3	**Gravitation and Central Force Motion:** Kepler's Laws. Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts. Motion of a particle under a central	14

	force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. **Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.	
4	**Special Theory of Relativity:** Galilean transformations; Galilean invariance. Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. **Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.	14

TEXT BOOKS

• Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

• Fundamentals-of-Physics-I-Mechanics, R. Shankar, 2014, Yale University Press

•An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

• Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

• Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.

• Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education

• Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

• Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

• University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

• Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning

• Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Physics Laboratory-I

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 103 CC 0042</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">● Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
● To study the random error in observations.
● To determine the height of a building using a Sextant.
● To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
● To determine the Moment of Inertia of a Flywheel.
● To determine g and velocity for a freely falling body using Digital Timing Technique</td><td>30</td></tr>
<tr><td>2</td><td colspan="6">● To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
● To determine Young's Modulus of a Wire by Optical Lever Method.
● To determine Modulus of Rigidity of a Wire by Maxwell’s needle.
● To determine the elastic Constants of a wire by Searle’s method.
● To determine the value of g using Bar Pendulum.
● To determine the value of g using Kater’s Pendulum.</td><td>30</td></tr>
<tr><td colspan="8">TEXT BOOKS
● Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
● Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
● Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.</td></tr>
</table>

Introduction to Computer Programming

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Introduction to Computer Programming</td><td>L</td><td>T</td><td>P</td><td>C</td><td colspan="2" rowspan="2">Semester: I</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 104 CC 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="4">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="4">Prerequisite of Course: None</td></tr>
<tr><td>#</td><td colspan="7">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="7">Introduction and Overview: Computer Architecture and organization; memory and input/output devices; Number system and computer arithmetic.
Programming with C++: Introduction to the concept of Object Oriented Programming, advantages of C++ over conventional programming languages, tokens, keywords, basic data-types, variable declaration, operators, classes and objects, C++ programming syntax for input/output, control structures: selection structure and loop structure, operators, simple and inline functions, arrays.
● Program to perform basic arithmetic operations on two numbers entered by user
● Use of decision structures: if, if-else, nested if-else and case statements.
● To find the largest number out of two/three numbers
● Programs based on use of loop structure: for and while statements.
● To find the roots of a quadratic equation.
● Programs based on use of 1-D/2-D arrays and to perform basic arithmetic operations.
● To find the standard deviation, mean, variance and moments for a set of numbers.</td><td>30</td></tr>
<tr><td>2</td><td colspan="7">Introduction to mathematical tools: Solution of ordinary differential equations (ODEs): Euler method, modified Euler method, RK methods; Numerical integration of 1D function: Trapezoidal and Simpson's rules.</td><td>30</td></tr>
</table>

	● Program to perform numerical integration of a one-dimensional function using Trapezoidal and Simpson's rules ● Numerical solution of ODEs using Euler's method, modified Euler's method and RK method of 4^{th} order. ● Motion of spherical body falling in (a) viscous medium (b) air ● Projectile motion of a body with horizontal/angular projection. ● Motion of a charged particle in uniform electric/magnetic field, and crossed electric and magnetic field. ● Study of charging and discharging of a capacitor in RC circuit with DC source.	

TEXT BOOKS

- Chandra, S. 2005. Computer Applications in Physics. II Edition. New Delhi: Narosa Publication House.
- Verma R.C., Ahluwalia, P.K., Sharma, K.C. 2000. Computational Physics. I Edition. New Delhi: New Age International Publishers.
- Balagurusamy E. 2015. Object Oriented Programming with C++. VI Edition. New Delhi: McGraw Hill Ed. (India).

Electricity and Magnetism

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Electricity and Magnetism</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 201 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Knowledge of Vector Algebra & Vector Calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Electricity and Magnetism which covers the topics of Electric Field and Electric Potential, Electrostatic energy of system of charges, Dielectric Properties of Matter, Magnetic Field, Magnetic Properties of Matter, Electromagnetic Induction, Electrical Circuits, Network Theorems and Ballistic Galvanometer</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course will help in understanding basic concepts of electricity and magnetism and their applications.
● Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, the student should be able to
● Demonstrate Coulomb’s law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
● Explain and differentiate the vector (electric fields, Coulomb’s law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
● Apply Gauss’s law of electrostatics to solve a variety of problems.
● Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Electric charges and Coulomb's law:** Electric charge, types and properties of electric charge, Coulomb’s law and its applications: electric field due to a uniformly charged infinite wire, circular ring (at a point on its axis), circular disc (at a point on its axis), infinite long plane sheet; electric lines of force, electric moments of a charge, electric dipole and electric field due to an electric dipole. **Gauss's law & its applications:** Electric flux, solid angle: solid angle subtended by a sphere at a point (i) inside it and (ii) outside it, solid angle subtended by a closed surface at a point inside it, Gauss's law and its applications: electric field due to a uniformly charged infinite wire, infinite non-conducting sheet, spherical shell, solid sphere; Coulomb’s law from Gauss's law, Force and torque on an electric dipole in an electric field.	15
2	**Electrostatic potential:** Conservative nature of electrostatic field, electric potential difference, electric potential, potential due to a point charge and a set of charges, potential as line integral of field, field as gradient of a scalar function, electric potential due to a uniformly charged wire, circular ring (at a point on its axis), circular disc (at a point on its axis), spherical shell, solid sphere, electric dipole, Uniqueness theorem, Laplace’s equation, Poisson’s equation, Electrostatic potential due to an arbitrary charge distribution and multipole moments, electrostatic potential energy of a charge in electric field, potential energy of a system of charges, potential energy of a charged sphere, equipotential surfaces, method of images and its application to a point charge near an earthed conducting (i) plane sheet and (ii) a sphere. **Electrostatic Fields in Dielectrics:** Dielectrics, polar and non-polar dielectrics, response of dielectric materials in external electric field, electric field due to polarization, polarization vector, dielectric constant, capacity of a parallel plate capacitor filled with dielectric, dielectric strength, electric susceptibility, free and bound charges, relation between (i) polarization vector and polarization charge densities, (ii) dielectric constant and electric susceptibility, atomic polarizability, Gauss's law for dielectrics, energy stored in a capacitor.	15
3	**Magnetic Field:** Force on a current-carrying wire in a magnetic induction field, torque on a current loop in a uniform magnetic field, current loop as magnetic dipole, Biot-Savart's law and its applications:	15

	magnetic field due to current-carrying straight wire, circular loop (at a point on its axis), solenoid; magnetic lines of force, force on parallel current carrying wire, magnetic flux, Ampere's circuital law and its application to solenoid and a toroid, curl and divergence of magnetic field, magnetic vector potential, divergence of vector potential, Hall effect. **Magnetic Fields in Matter:** Magnetization vector (**M)**. Magnetic intensity **(H),** magnetic susceptibility and permeability, relation between **B, H** and **M**, properties paramagnetic, diamagnetic and ferromagnetic materials, B-H curve and hysteresis.	
4	**Electromagnetic Induction:** Introduction, Faraday's laws of electromagnetic induction, Lenz's law, self-inductance and mutual inductance, reciprocity theorem, energy stored in an inductor, Ampere's law for varying currents: need for its modification, modification of Ampere's law, displacement current and Maxwell's equations, series LCR Circuit and parallel LCR Circuit: resonance, power dissipation, quality factor and band width; maximum power transfer theorem. **Electrical Circuits:** AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: Resonance, Power Dissipation, Quality Factor, and Band Width. Parallel LCR Circuit. **Network Theorems:** Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.	15

TEXT BOOKS

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 2017, McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 2012, Pearson Prentice Hall.
4. Feynman Lectures Vol. II, R.P.Feynman, R.B.Leighton, M. Sands, 2012, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2015, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Waves and Optics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Waves and Optics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 202 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to introduce the student to a broad range of physical phenomena involving waves (including mechanical waves, sound waves, and electromagnetic waves), coherence, interference and diffraction phenomena</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn the basics of wave motion.
● Know about the behavior of light due to its wave nature.
● Identify and understand different phenomena due to the interaction of light with light and matter.
● Analyze some of the fundamental laws and principles of light which is used in many important optical instruments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Enable the students to analyze different phenomena due to the interaction of light with light and matter.
● Train the students to use different optical instruments.
● Help the students to understand various natural phenomena using different apparatus in the laboratory.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**SHM:** Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **Superposition of Harmonic Oscillations:** (a) Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. (b) Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.	15
2	**Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves **Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **Superposition of Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. (b) Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. (c) Superposition of N Harmonic Waves. Phase and Group Velocities.	15
3	**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);	15

	Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	
4	**Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. **Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	15

TEXT BOOKS

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
- A textbook of Optics; N Subramanyam, B. Lal and M.N.Avadhanulu; S.Chand Publishing.

Physics Laboratory-II

Scheme Version:	**Name of the subject:**	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:**
2022-27	Physics Laboratory-II	0	0	8	4	**II**	8
							Total Hours: 120
Subject Code: SBS PHY 03 203 CC 0084	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours (Practical)		
			TEE	70 Marks	**Prerequisite of Course:** None		

#	List of Experiments	Hours
1	1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses. 2. To study the characteristics of a series RC Circuit. 3. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth. 4. To study the response curve of a parallel LCR circuit and determine its (a) anti-resonant frequency and (b) Quality factor Q. 5. Conversion of galvanometer to voltmeter and ammeter. 6. To determine the frequency of AC mains using a sonometer. 7. To determine an unknown Low Resistance using a Potentiometer. 8. To determine an unknown Low Resistance using Carey Foster's Bridge. 9. To compare capacitances using De'Sauty's bridge. 10. Measurement of field strength B and its variation in a solenoid (determine dB/dx) 11. To verify the Thevenin and Norton theorems. 12. To verify the Superposition and Maximum power transfer theorems. 13. To determine the self-inductance of a coil by Anderson's bridge.	60

	14. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer 15. Determine a high resistance by leakage method using Ballistic Galvanometer. 16. To determine the self-inductance of a coil by Rayleigh's method. 17. To determine the mutual inductance of two coils by the Absolute method.	
2	1. To investigate the motion of coupled oscillators 2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda 2 - T$ Law. 3. To study Lissajous Figures 4. Familiarization with Schuster`s focussing; determination of angle of prism. 5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method). 6. To determine the Refractive Index of the Material of a Prism using Sodium Light. 7. To determine Dispersive Power of the Material of a Prism using Mercury Light 8. To determine the value of Cauchy Constants. 9. To determine the Resolving Power of a Prism. 10. To determine wavelength of sodium light using Fresnel Biprism. 11. To determine wavelength of sodium light using Newton's Rings. 12. To determine the wavelength of Laser light using Diffraction of Single Slit. 13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating 14. To determine the Resolving Power of a Plane Diffraction Grating. 15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.	60

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Mathematical Physics–II

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Mathematical Physics–II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 301 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
10+2 level Mathematics and course of Mathematical Physics-I in Semester I</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Fourier Series, Special Functions, Special Integrals, Theory of Errors, and Partial Differential Equations and its applications in Physics to the students.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Training in mathematical tools like calculus, integration, series solution approach, special function will prepare the student to solve ODE, PDE’s which model physical phenomena.
● The student shall develop an understanding of how to model a given physical phenomena such as pendulum motion, rocket motion, stretched string, etc., into set of ODE’s, PDE’s and solve them.
● These skills will help in understanding the behavior of the modeled system/s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
● Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
● Learn the beta, gamma and the error functions and their applications in doing integrations.
● Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics.
● Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Fourier Series** : Periodic functions. Orthogonality of sine and cosine functions, DirichletConditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	15
2	**Frobenius Method and Special Functions** : Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality	20
3	**Some Special Integrals**: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **Theory of Errors**: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line	10
4	**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.	15

TEXT BOOKS

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Thermal Physics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Thermal Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 302 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
High School Mathematics & Fundamental Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand the relations between the macroscopic properties of physical systems in equilibrium. The course evaluates the concepts of thermodynamics learnt at school in more advanced perception and develops them further.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamental laws of thermodynamics and their applications to various systems and processes
● To understand the concepts of entropy, thermodynamic potentials and Maxwell's thermodynamic relations
● To give exposure about the kinetic theory of gases, transport phenomena involved in ideal gases, phase transitions and behavior of real gases
● To able the students for solve the problems related to thermodynamics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Grasp the basic concepts and fundamental laws of thermodynamics.
● Understand the concepts of entropy, reversible and irreversible processes, thermodynamic potentials and Maxwell's relations and their physical interpretations.
● Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equipartition theorem, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
● Understand the concept and behavior of ideal and real gases.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes. **Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	18
2	**Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Third Law of Thermodynamics. Unattainability of Absolute Zero. **Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations. Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of Cp-Cv	18
3	**Distribution of Velocities:** Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and	12

	Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.	
4	**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapor and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.	12

TEXT BOOKS

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
- Thermal Physics, B.K. Agrawal, Lok Bharti Publications.

Analog Systems and Applications

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Analog Systems and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 303 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="8">This course is aimed at understanding of PN Junctions, BJT, MOSFETs, Op-Amps as well as their applications in the Analog domain.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">● To know about the basics of semiconductor PN junction, its various types and its applications to various electronic circuits.
● To understand the properties, working and applications of bipolar junction transistor as amplifier and oscillators.
● To Familiarize with operational amplifiers, its applications and analysis
● To develop knowledge about analog to digital and digital to analog conversion techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After completion of this course, students would be able to:
● Learn the foundation knowledge of analog electronic systems.
● Learn the working and applications of PN junction and bipolar junction transistors (BJT).
● Learn to analyze circuits containing PN junction and BJT along with the application of BJT as amplifiers and oscillators.
● Develop basic knowledge of operational amplifier and its applications.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.	15
2	**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains.	15
3	Classification of Class A, B & C Amplifiers. **Coupled Amplifier:** RC-coupled amplifier and its frequency response. **Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	15
4	**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.	15

	Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)	

TEXT BOOKS

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning.
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

Physics Laboratory-III

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-III</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III</td><td>Contact Hours per Week:
12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours:
180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 304 CC 00126</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

#	List of Experiments	Hours
1	1. To study V-I characteristics of PN junction diode, and Light emitting diode. 2. To study the V-I characteristics of a Zener diode and its use as voltage regulator. 3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency. 4. To study the characteristics of a Bipolar Junction Transistor in CE configuration. 5. To study the various biasing configurations of BJT for normal class A operation. 6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. 7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier. 8. To design Wien bridge oscillator for given frequency using op-amp. 9. To design a phase shift oscillator of given specifications using BJT. 10. To study the Colpitt`s oscillator. 11. To design a digital to analog converter (DAC) of given specifications.	60

	12. To study the analog to digital convertor (ADC) IC. 13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain 14. To design inverting amplifier using Op-amp (741,351) and study its frequency response 15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response 16. To study the zero-crossing detector and comparator 17. To add two dc voltages using Op-amp in inverting and non-inverting mode 18. To design a precision Differential amplifier of given I/O specification using Op-amp. 19. To investigate the use of an op-amp as a Differentiator/Integrator. 20. To design a circuit to simulate the solution of a 1st/2nd order differential equation.	
2	1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method. 2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus. 3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method. 4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and 5. Charlton's disc method. 6. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT). 7. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions. 8. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature	60
3	**Random number generation and its applications:** mid square method and multiplicative congruential method; Monte-Carlo simulations. List of exercise (using C++) ● Generation of random numbers using the mid-square method and multiplicative congruential method. ● Monte-Carlo technique to evaluate the value of Pi.	60

	• Monte-Carlo technique to simulate the phenomenon of nuclear radioactivity. **Additional Mathematical Physics problems (using C++) based on:** • Dirac Delta Function, Fourier Series • Frobenius methods and Special functions • Calculation of error for each data point of observations recorded in experiments done earlier • Calculation of least square fitting manually without giving weightage to error. • Compute the nth roots of unity for n = 2, 3, and 4. • Find the two square roots of −5+12j.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Chandra, S. 2005. Computer Applications in Physics. II Edition. New Delhi: Narosa Publication House.
- Verma R.C., Ahluwalia, P.K., Sharma, K.C. 2000. Computational Physics. I Edition. New Delhi: New Age International Publishers.
- Balagurusamy E. 2015. Object Oriented Programming with C++. VI Edition. New Delhi: McGraw Hill Ed. (India).

Mathematical Physics-III

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Mathematical Physics-III</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 401 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics-I and Mathematical Physics-II</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Complex Analysis, Integrals Transforms, Fourier Transforms, Laplace Transform and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Knowledge of various mathematical tools like complex analysis, integral transform will equip the student with reference to solve a given ODE, PDE.
● These skills will help in understanding the behavior of the modeled system/s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn about the complex numbers and their properties, functions of complex numbers and their properties such as analyticity, poles and residues. The students are expected to learn the residue theorem and its applications in evaluating definite integrals.
● Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Complex Analysis-I: Brief Revision of Complex Numbers and their GraphicalRepresentation. Euler's formula, De Moivre's theorem, Roots</td><td>12</td></tr>
</table>

	of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions.	
2	**Complex Analysis-II:** Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.	12
3	**Integrals Transforms:** Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.	18
4	**Laplace Transforms:** Laplace Transform (LT) of Elementary functions. Properties ofLTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	18

TEXT BOOKS

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3 rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8 th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7 th Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Elements of Modern Physics

<table>
<tr><td rowspan="2">Scheme Version :

2022-27</td><td rowspan="2">Name of the subject:
Elements of Modern Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 402 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of One dimensional potential problem of bound states and scattering and elementary introduction of nuclear physics with emphasis on

(i) Nuclear Structure
(ii) Nuclear Forces
(iii) Nuclear Decays
(iv) Fission and Fusion</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To Comprehend the failure of classical physics and need for quantum physics.
● To Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.
● To Formulate the basic theoretical problems in one, two and three dimensional physics and solve them.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
● Understand the theory of quantum measurements, wave packets and uncertainty principle.
● Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and</td></tr>
</table>

	time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier. ● Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Planck's Postulate, and wave and particle like properties of radiation:** Relation of quantum physics to classical physics: Theory of cavity radiation, Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.	15
2	**Heisenberg uncertainty principle and Schrodinger theory:** Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.	15
3	**Solution of Schrodinger equation for one dimensional problems:** One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.	14

	Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.	
4	**Nuclear models:** Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **Radioactivity:** stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. **Fission and fusion:** mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions)	16

TEXT BOOKS

• Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
• Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
• Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
• Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
• Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
• Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
• The Picture Book of Quantum Mechanics, S. Brandt and H. D. Dahmen, 2012, Springer; 4th edn
• Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
• Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
• Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
• Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
• Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill
• Quantum Mechanics, J. L. Powell and B. Crasemann, Dover Publications, 2015.

Digital Systems and Applications

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Digital Systems and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 403 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to provide a complete insight into the modern design of digital systems fundamentals from an eminently practical point of view. It will allow students to lay the foundation for the design of complex digital systems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To know about the basic laboratory equipment electronics.
● To understand basic digital electronics concepts and devices.
● To analyze digital circuits.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Identify and understand digital electronic principles and systems.
● Apply the knowledge to analyze and apply digital circuits in solving circuit level problems.
● Build real life applications using digital systems.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.
Integrated Circuits: (a) Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.</td><td>18</td></tr>
</table>

	Digital Circuits: (a) Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers **Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	
2	**Data processing circuits:** (a) Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop	15
3	**Timers:** (a) IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **Shift registers:** (a) Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **Counters (4 bits):** (a) Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **Computer Organization:** (a) Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map	15
4	**Intel 8085 Microprocessor Architecture:** Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **Introduction to Assembly Language:** 1 byte, 2 byte & 3 byte instructions.	12

TEXT BOOKS

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.

- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1 st edition, McGraw Hill
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Physics Laboratory-IV

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-IV</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 404 CC 00126</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>150 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
</table>

#	List of Experiments	Hours
1	1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO. 2. To test a Diode and Transistor using a Multimeter. 3. To design a switch (NOT gate) using a transistor. 4. To verify and design AND, OR, NOT and XOR gates using NAND gates. 5. To design a combinational logic system for a specified Truth Table. 6. To convert a Boolean expression into logic circuit and design it using logic gate ICs. 7. To minimize a given logic circuit. 8. Half Adder, Full Adder and 4-bit binary Adder. 9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C. 10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates. 11. To build JK Master-slave flip-flop using Flip-Flop ICs 12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram. 13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs. 14. To design an astable multivibrator of using 555 Timer. 15. To design a monostable multivibrator using 555 Timer. 16. Write the following programs using 8085 Microprocessor a) Addition and subtraction of numbers using direct addressing mode	60

	b) Addition and subtraction of numbers using indirect addressing mode c) Multiplication by repeated addition. d) Division by repeated subtraction. e) Handling of 16-bit Numbers. f) Use of CALL and RETURN Instruction. g) Block data handling. h) Other programs (e.g. Parity Check, using interrupts, etc.).	
2	1. Measurement of Planck's constant using black body radiation and photo-detector 2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light 3. To determine work function of material of filament of directly heated vacuum diode. 4. To determine the Planck's constant using LEDs of at least 4 different colours. 5. To determine the wavelength of H-alpha emission line of Hydrogen atom. 6. To determine the ionization potential of mercury. 7. To determine the absorption lines in the rotational spectrum of Iodine vapour. 8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet. 9. To setup the Millikan oil drop apparatus and determine the charge of an electron. 10. To show the tunneling effect in tunnel diode using I-V characteristics. 11. To determine the wavelength of laser source using diffraction of single slit. 12. To determine the wavelength of laser source using diffraction of double slits. 13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating	60
3	**Introduction to Numerical computation software Scilab:** Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization, User defined functions.	60

	Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays; An introduction to Scilab file processing, file opening and closing, Binary I/O functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program. **Exercises (using Scilab) based on:** ● Curve fitting, Least square fit, Goodness of fit, standard deviation ● Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems. ● Generation of Special functions using and User defined functions in Scilab ● Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods, Second order differential equation, Fixed difference method, Partial differential equations	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- www.scilab.in/textbook_companion/generate_book/291

Quantum Mechanics and Applications

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Quantum Mechanics and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 501 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of time dependent Schrodinger equation, time independent Schrodinger equation. There will be a detailed discussion of bound states in an arbitrary potential. Quantum Theory of hydrogen-like atoms will be developed. The behavior of atoms in Electric and Magnetic Fields is discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course shall develop an understanding of how to model a given problem such as particle in a box, hydrogen atom, hydrogen atom in electric fields.
● Many electron atoms, L-S and J-J couplings.
● These skills will help in understanding the different Quantum Systems in atomic and nuclear physics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
● Through understanding the behavior of quantum particle encountering a i) barrier, ii) potential.
● Student gets exposed to solving non-relativistic hydrogen atom, and multi-electrons systems for their spectrum and eigenfunctions.</td></tr>
</table>

	● Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Time dependent Schrodinger equation:** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **Time independent Schrodinger equation-**Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.	16
2	**General discussion of bound states in an arbitrary potential-** continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite Polynomials; ground state, zero point energy & uncertainty principle.	12
3	**Quantum theory of hydrogen-like atoms:** time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first	18

	excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. **Many electron atoms:** Pauli's Exclusion Principle. Symmetric & Antisymmetric WaveFunctions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and AlkaliAtoms (Na, etc.).	
4	**Atoms in Electric & Magnetic Fields:** Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern- Gerlach Experiment. Zeeman Effect. Orbital angular momentum, General Formalism of Angular Momentum, Addition of Angular Momenta, Spin Angular Momentum: Stern-Gerlach Experiment; Pauli Matrices and Spinors, Clebsch-Gordan Coefficients.	14

TEXT BOOKS

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Principles of Quantum Mechanics, R. Shankar, Springer; 2nd ed., 2014
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Solid State Physics

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Solid State Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 502 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Modern Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory, magnetism, ferroelectricity, and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.
● To understand the fundamentals of dielectric, ferroelectric and magnetism phenomenon in solids
● To make acquainted with several types of electric and magnetic materials and their exciting properties
● To develop the scientific and positive attitudes in students related to the materials science which is a part of solid-state physics
● To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Identify various crystal structures and their symmetries in solids and learn the basic concepts of X-ray diffraction, rotating crystal, and Laue methods.
● Explain the theories and phenomena of lattice dynamics, and thermal properties (specifically specific heat) in solids
● Calculate the specific heat and density of states of various solids and recognize the importance of band theory, effective mass, Hall effect etc. in solids.</td></tr>
</table>

	● Explain the dielectric phenomenon in crystals with their exciting properties and learn the basics of ferroelectric crystals. ● Describe the diamagnetism, paramagnetism, and ferromagnetism phenomenon in solids, CO.6. Illustrate some exciting phenomena such as Meissner effect, Isotope effect, London's equations, and BCS theory of superconductors.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Ewalds' construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.	14
2	**Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T3 law. **Electrons in Solids:** Electrons in metals- Introduction to Drude Model, Density of states (1-D, 2-D, 3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).	20
3	**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	14
4	**Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Para- magnetism. Hunds's rule. Weiss's Theory of Ferromagnetism and Ferromagnetic	12

	Domains. Curie's law. B-H Curve. soft and hard material and Energy Loss Hysteresis. **Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)	

TEXT BOOKS

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Physics Laboratory-V

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-V</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
8</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours:
120</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 503 CC 0084</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="5">List of Experiments</td><td colspan="2">Hours</td></tr>
<tr><td>1</td><td colspan="5">1. Measurement of susceptibility of paramagnetic solution (Quinck’s Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 1500C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.</td><td colspan="2">40</td></tr>
</table>

	12. Measurement of change in resistance of a semiconductor with magnetic field.	
2	1. Study of Electron spin resonance- determine magnetic field as a function of the resonance 2. frequency 3. Study of Zeeman effect: with external magnetic field; Hyperfine splitting 4. To show the tunneling effect in tunnel diode using I-V characteristics. 5. Quantum efficiency of CCDs	20
3	1. Determine output characteristics of a LVDT & measure displacement using LVDT 2. Measurement of Strain using Strain Gauge. 3. Measurement of level using capacitive transducer. 4. To study the characteristics of a Thermostat and determine its parameters. 5. Study of distance measurement using ultrasonic transducer. 6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75) 7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD). 8. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope. 9. To design and study the Sample and Hold Circuit.To plot the frequency response of a microphone. 10. To measure Q of a coil and influence of frequency, using a Q-meter.	30
4	**Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like** **1.** Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: $\frac{dy^2}{dr^2} = A(r)u(r),$ where $A(r) = \frac{2m}{\hbar}[V(r) - E]$, and $V(r) =- \frac{e^2}{r}$ Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that	30

	the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $\sqrt{(eVÅ)}$, ħc = 1973 (eVÅ) and m = 0.511x106 eV/c^2. **2.** Solve the s-wave radial Schrodinger equation for an atom: $\frac{dy^2}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{ħ}[V(r) - E]$, where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential $V(r) =- \frac{e^2}{r}e^{(-r/a)}$. Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $\sqrt{(eVÅ)}$, m = 0.511×10^{-6} eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases. **3 .** Solve the s-wave radial Schrodinger equation for a particle of mass m: $\frac{dy^2}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2m}{ħ}[V(r) - E]$, For the anharmonic oscillator potential $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$ for the ground state energy (in MeV) of a particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3} In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases. **4.** Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule: $\frac{dy^2}{dr^2} = A(r)u(r)$, where $A(r) = \frac{2μ}{ħ}[V(r) - E]$,Where μ is the reduced mass of the two-atom system for the Morse potential $V(r) = D\left[e^{-2\alpha r'} - e^{-\alpha r'}\right]$, $r' = \frac{r-r_0}{r}$ Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.Take: m = 940x106 eV/c^2, D = 0.755501 eV, α = 1.44, r_0= 0.131349 Å	
	TEXT BOOKS	

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw‐Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Electromagnetic Theory

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Electromagnetic Theory</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 601 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Thermal Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course provides Review of Maxwell’s equations and discuss EM wave propagation in unbounded media of various types. The polarization of electromagnetic waves, wave guides, and optical fibres are discussed in detail.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Comprehend the role of Maxwell’s equation in unifying electricity and magnetism.
● Derive and understand associated with the properties, EM wave passing through the interface between two media like Reflection, Refraction, Transmission and EM wave
● Learn the application of EM theory to
(i) Wave guides of various types
(ii) Optical fibers in theory and experiment</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Apply Maxwell’s equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
● Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
● Understand the linear, circular and elliptical polarization of em waves. Production as well as detection of waves in the laboratory.
● Learn about optical fibers and waveguides.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Maxwell Equations:** Review of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **EM Wave Propagation in Unbounded Media:** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gasses, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	14
2	**Reflection of a plane EM Wave at a planar boundary:** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, Metallic reflection (normal Incidence) **Reflection of an evanescent EM Wave at planar boundary:** Introduction to evanescent waves. Reflection & Refraction of an EM evanescent wave at plane interface between two dielectric media, Energy propagation in evanescent EM waves.	14
3	**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light.	16

	Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	
4	**Wave Guides:** Planar optical waveguides. Planar dielectric waveguide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **Optical Fibres:-** Numerical Aperture. Step and Graded Indices (Definitions Only).Single and Multiple Mode Fibres	12

TEXT BOOKS

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Classical Electricity and Magnetism, W. Panofsky and M. Phillips, 2012.Dover publications
- Principles of Optics, M. Born and E. Wolf, 1999, Cambridge University Press.
- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Evanescent Waves, F. de Fornel, 2001, Springer-Verlag Berlin Heidelberg
- Understanding energy propagation during reflection of an evanescent electromagnetic wave: Am. J. Phys., 89, 877 (2021)
- Microwave Devices and Circuits, Samuel Y. Liao, Pearson Education India; 3rd edn, 2003

Statistical Mechanics-I

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 602 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Thermal Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course introduces the techniques of statistical mechanics which has broad and rich applications in various fields including quantum mechanics, condensed matter physics, classical mechanics, astrophysics, bio-physics, electrodynamics, etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of statistical mechanics
● To make familiar with various statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.
● To understand the basic aspects of theory of radiation
● To able the students for solve the problems related to statistical mechanics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Understand the concepts of macro and micro states, phase space, thermodynamic probability, partition function etc. and apply the thermodynamic probability and partition function to calculate the thermodynamic variables for ideal gas and finite level system.
● Illustatre the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics
● Apply FD and BE statistics in various model problems (electron in solids, white dwarf blackbody radiation and helium gas).
● Understand the properties and laws related with thermal radiation.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	16
2	**Bose-Einstein Statistics:** B-E Distribution law, Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	20
3	**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly degenerate Fermi Gas, Fermi Energy Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	12
4	**Theory of Radiation:** Properties of Thermal Radiation and Radiation Pressure. Blackbody Radiation and its spectral distribution. Kirchhoff law. Stefan-Boltzmann law and its Thermodynamic proof. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law and Wien's Displacement law from Planck's law.	12

TEXT BOOKS

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2 nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Physics Laboratory-VI

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-VI</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester: V</td><td>Contact Hours per Week: 8</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours: 120</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 603 CC 0084</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course: None</td></tr>
</table>

<table>
<tr><th>#</th><th>List of Experiments</th><th>Hours</th></tr>
<tr><td>1</td><td>1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston’s airfilm.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection
using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for airglass
interface.</td><td>90</td></tr>
</table>

	11. To verify the Stefan`s law of radiation and to determine Stefan's constant. 12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.	
2	***Use C/C++/Scilab/Python and other numerical simulations for solving the problems based on Statistical Mechanics like*** 1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature. 2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases. 3. Plot Maxwell-Boltzmann distribution function versus temperature. 4. Plot Fermi-Dirac distribution function versus temperature. 5. Plot Bose-Einstein distribution function versus temperature.	30

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. 2007, Wiley India Edition.
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.

DSE PAPERS

Experimental Techniques

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Experimental Techniques</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week:
8 (4,4)</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
120 (60,60)</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 501 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 (30,15) Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 (70,35) Marks</td><td colspan="3">Prerequisite of Course:
Knowledge of basic electronics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Accuracy and precision, Different types of errors and statistical analysis of data, Noise and signal, signal to noise ratio, different types of noises, Electromagnetic interference and necessity of grounding, Transducer, Different types of transducers and sensors, Digital multimeter and Vacuum systems including ultrahigh vacuum systems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Develop skills to analyse data, make approximation and perform error analysis using basic methods of statistics.
Learn the working principle of transduces, their application and study of the efficiency.
Develop understanding of analog and digital instruments and earn to use them in making physical measurements.
Develop their understanding of signal, noise, and fluctuations in making physical measurements.
Understanding of Impedances Bridges, Q meters as well as vacuum systems using various types of pumps and pressure gauges.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
About accuracy and precision, different types of errors and statistical analysis of data.
About Noise and signal, signal to noise ratio, different types of noises and their identification.</td></tr>
</table>

	● Concept of electromagnetic interference and necessity of grounding. ● About transducers and basic concepts of instrumentation-Different types of transducers and sensors. ● Working of a digital multimeter. ● Vacuum systems including ultrahigh vacuum systems. ● Conduct Experiments using different transducers including LVDT and gain hands on experience and verify the theory.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Measurements: Accuracy and precision**. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. **Signals and Systems**: Periodic and aperiodic signals. Impulse response, transfer functionand frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise. **Shielding and Grounding**: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.	**20**
2	**Transducers & industrial instrumentation (working principle, efficiency, applications):** Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filleddetector, ionization chamber, scintillation detector.	**20**

3	**Digital Multimeter**: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement **Impedance Bridges and Q-meter**: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.	**20**
4	**Vacuum Systems**: Characteristics of vacuum: Gas law, Mean free path. Application ofvacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).	**15**

TEXT BOOKS

- Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

Biophysics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Biophysics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 502 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Molecules of Life, The complexity of Life and Evolution

.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Basic concepts about biological physics and evolution are learned.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Acquire mastery of the fundamental principles and applications of various branches of Physics in understanding biological systems.
● Nuggets of thermodynamics and statistical mechanics, electricity and magnetism, will help in understating heat transfer in biomaterials.
● Relevance of chemistry principles and thermodynamics in understanding energy transfer mechanism and protein folding in biological systems.
● He /she will acquire necessary mathematical skills in differential equations, analysis, and linear algebra for simulation studies.
● A basic course in bioPhysics will provide proficiency in basic lab skills, includin understanding and using modern instrumentation and computers.
● Get exposure to complexity of life at i) the level of Cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Overview:** The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self- replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.	18
2	**Molecules of life:** Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally	18
3	**The complexity of life:** At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development. Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.	21

4	**Evolution:** The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.	18

TEXT BOOKS

- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
- Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)
- Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
- An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
- Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Earth Sciences

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Earth Sciences</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week:
6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 503 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge The Earth and the Universe, Structur, Dynamical Processes, Evolution and Contemporary dilemmas: Disturbing the Earth</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Knowledge of the place of Earth in this Universe and its formation, structure and its evolution shall enable the student to appreciate the reasons for keeping Earth ‘SAFE’</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to learn:
about origin of Universe, place of Earth as a third rock revolving around Sun, its satellite Moon and in general evolution of present day Universe.
overview of the structure and evolution of the Earth as a dynamic planet within our solar system
Application of physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure. The origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top layer shall be understood.
Climate and various roles played by water cycle, carbon cycle, nitrogen cycles in maintain steady state of earth shall be explored.
This will enable the student to understand the contemporary dilemmas (climate change, biodiversity loss, population growth, etc.) disturbing the Earth</td></tr>
</table>

	● In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, student will be to appreciate need to 'save' Earth.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**The Earth and the Universe:** (a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. (b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. (c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.	18
2	**Structure:** (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior? (b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems. (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds. (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers. (e) The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms	18
3	**Dynamical Processes:** (a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea- floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.	18

	(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis. (c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones. **Climate:** i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system. (d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state	
4	**Evolution:** Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent. 1. Time line of major geological and biological events. 2. Origin of life on Earth. 3. Role of the biosphere in shaping the environment. 4. Future of evolution of the Earth and solar system: Death of the Earth. **Disturbing the Earth – Contemporary dilemmas** (a) Human population growth. (b) Atmosphere: Green house gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.	21

TEXT BOOKS

- Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.
- Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books
- Holme's Principles of Physical Geology. 1992. Chapman & Hall.
- Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Nuclear and Particle Physics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Nuclear and Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 504 DS 5106</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:
Elements of Modern Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of General properties of nuclei, Nuclear models, Radioactive decays, Nuclear reactions, Interaction of nuclear radiation with matter, Detectors for nuclear interaction, Particle accelerators and Elementary particles and their properties.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.
To understand, explain and derive the various theoretical formulation of nuclear disintegration like α decay, β decay and decays.
Develop basic understanding of nuclear reactions and decays with help of theoretical formulate and laboratory experiments.
Skills to develop basic understanding of the interaction of various nuclear radiation with matter in low and high energy</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.
Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell</td></tr>
</table>

	model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles. ● Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays, the properties of the constituents of these rays and the mechanisms of the emissions of these rays, outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series. ● Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential. ● Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation. ● Learn about the detectors of nuclear radiations- the Geiger-Mueller counter, the scintillation counter, the photo-multiplier tube, the solid state and semiconductor detectors.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**General Properties of Nuclei**: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic nuclear excites states. moment, electric moments, **Nuclear Models**: Liquid drop model approach, semi empirical mass formula andsignificance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	20
2	**Radioactivity decay**: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b)[] -decay: energy kinematics for []- decay, positron	15

	emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **Nuclear Reactions**: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	
3	**Interaction of Nuclear Radiation with matter:** Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interactionwith matter. **Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	20
4	**Particle Accelerators**: Accelerator facility available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **Particle physics**: Particle interactions; basic features, types of particles and its families.Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quarkmodel, color quantum number and gluons.	20

TEXT BOOKS

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Atmospheric Physics

Scheme Version: 2022-27	Name of the subject: Atmospheric Physics	L	T	P	C	Semester: V	Contact Hours per Week: 6
		5	1	0	6		Total Hours: 75
Subject Code: SBS PHY 03 505 DS 5106	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 150)**	**CIE**	45 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	105 Marks	**Prerequisite of Course:**		
Course Description	This course aims at providing knowledge of General features of Earth's atmosphere, Atmospheric dynamics, Atmospheric waves, Atmospheric Radar and Lidar and Atmospheric Aerosols.						
Course Objectives	• Develop skills to describe, understand and make measurements of various parameters to describe the physics of earth's atmosphere. • Learn skills to formulate, solve the theoretical equations describing the atmospheric dynamics and develop software to simulate and demonstrate in laboratory the various atmospheric phenomenon like Atmospheric oscillations of various types and Atmospheric waves of various types.						
Course Outcomes	• Good knowledge of Earth's atmosphere, its composition, effective temperature, Greenhouse effect. Hydrostatic equation and atmospheric thermodynamics. Local winds, clouds, fog, monsoon, cyclones, sea breeze and land breeze and thunderstorms, etc. • Essential knowledge of the instruments of meteorological observation, meteorological processes and systems. • Understanding atmospheric dynamics, fundamental forces, conservation laws, rotating coordinate system and equations of motion. Circulation, vorticity, various types of circulations, atmospheric oscillations: biannual, annual and semi-annual oscillations. • Understanding atmospheric waves. Surface water waves, acoustic waves, buoyancy waves, atmospheric gravity waves (AGW) and its propagation in						

	non-homogeneous medium, Lamb and Rossy waves and their propagation in 3-dimension. Wave absorption and non linear effects. ● Skills to use atmospheric Radar and Lidar to study atmospheric phenomenon, basic knowledge of Radars and Lidars including Radar equation and signal processing. ● Develop numerical skills to do data analysis from Radar and Lidar. ● Knowledge of the classification and properties of aerosols, their concentrations and size distribution. Production and removal of aerosols. Radiative and health effects and observation techniques for aerosols. ● Understanding the absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Boyer-Lambert law, optical phenomenon in atmosphere. Basics of radiometry.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**General features of Earth's atmosphere**: Thermal structure of the Earth'sAtmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms	15
2	**Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservationlaws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. **Atmospheric Waves**: Surface water waves, wave dispersion, acoustic waves,buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and	20

	its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration	
3	**Atmospheric Radar and Lidar**: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.	10
4	**Atmospheric Aerosols**: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.	15

TEXT BOOKS

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press;3 rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S Fukao and KHamazu, Springer Japan, 2014

Physics of Devices and Instrumentation

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics of Devices and Instrumentation</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: V</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 506 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Metal oxide semiconductors, UJT, JFET, MOSFET, Charge coupled Devices and Tunnel Diode, Power Supply and the role of Capacitance and Inductance filters, Active and passive filters and various types of filters, Multivibrators using transistors, Phase locked loops, voltage controlled oscillator, Photolithography for IC fabrication, about masks and etching, Parallel and serial communications and USB standards and GPIB, Different modulation techniques.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Acquire knowledge and skills to understand the working of the following devices and instruments and practical knowledge to use them by doing experiments in the laboratory.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to Master the following:
● Metal oxide semiconductors, UJT, JFET, MOSFET, Charge coupled Devices and Tunnel Diode.
● Power Supply and the role of Capacitance and Inductance filters.
● Active and passive filters and various types of filters.
● Multivibrators using transistors, Phase locked loops, voltage controlled oscillators
● Basics of photolithography for IC fabrication, about masks and etching.
● Concepts of parallel and serial communication and knowledge of USB standards and GPIB.
● Basic idea of communication including different modulation techniques.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Devices**: Characteristic and small signal equivalent circuits of UJT and JFET. Metal- semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.	18
2	**Power supply and Filters:** Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **Multivibrators:** Astable and Monostable Multivibrators using transistors. **Phase Locked Loop(PLL)**: Basic Principles, Phase detector(XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046)	20
3	**Processing of Devices:** Basic process flow for IC fabrication, Electronic grade silicon.Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation	18
4	**Digital Data Communication Standards**: Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.	19

	Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK	

TEXT BOOKS

- Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3 rd Ed.2008, John Wiley & Sons
- Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
- Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd
- Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Introduction to Measurements & Instrumentation, A.K. Ghosh, 3 rd Ed., 2009, PHI Learning Pvt. Ltd.
- Semiconductor Physics and Devices, D.A. Neamen, 2011, 4 th Edition, McGraw Hill
- PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

Nano Materials and Applications

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Nano Materials and Applications</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 601 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course will familiarize the students to the science related to various phenomena observed at the nanoscale. Starting from an introduction to the basic ideas of nanoscience and nanotechnology, various examples will be discussed which highlight the impact of nanoscale on various properties of technological interest. Technologies built on these phenomena will be discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Provide a systematic coverage and insight into the promising area of nano materials in order to facilitate the understanding of the nature and prospects for the field.
● Provide information about various synthesis and characterization techniques of nano materials.
● Discuss optical and electronic transport properties of nano materials.
● Discuss applications of nano materials in various fields.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">This course will enable a student to
CO102C.1. Gather sufficient knowledge about the fascinating behaviour of nanomaterials and tuning of such properties for different applications.
CO102C.2. Obtain information on experimental methodologies with necessary theoretical background, which may be useful for pursuing further study on the areas of nanoscience and technology.</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **Synthesis of Nanostructure Materials:** Top down and Bottom up approach, Photolithography. Ball milling. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electrodeposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE	19
2	**Characterization:** X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **Electron Transport:** Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects	18
3	**Optical Properties:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.	18
4	**Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).	18

TEXT BOOKS

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

Medical Physics

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 602 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Physics of the Body, Physics of Diagnostic and Therapeutic Systems, Radiation Physics, Medical Imaging Physics, Radiation Oncology Physics, Radiation and Radiation Protection, and Physics of Diagnostic and Therapeutic Systems</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Essential physics of Medical Imaging, Radiological Physics, Therapeutic Systems and Radiation Therapy is acquired.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">This course will enable the student to:
● Focus on the application of Physics to clinical medicine.
● Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
● Learn about the human body, its anatomy, physiology and bioPhysics, exploring its performance as a physical machine. Other topics include the Physics of the senses.
● He / She will study diagnostic and therapeutic applications like the ECG, radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
● Gain knowledge with reference to working of various diagnostic tools , medical imaging techniques, how ionizing radiation interacts with matter, how it affects living organisms and how it is used as a therapeutic technique and radiation safety practices</td></tr>
</table>

	● Imparts functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Physics of Body-I:** Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics ofbody movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. Energy household of the body: Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. Pressure system of body: Physics of breathing, Physics of cardiovascular system. **Physics of Body-II:** Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. Optical system of the body: Physics of the eye. Electrical system of the body: Physics of the nervous system, Electrical signals and information transfer.	20
2	**Physics of Diagnostic and Therapeutic Systems-I: X-Rays:** Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. X-ray tubes & types: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit. Single and three phase electric supply. Power ratings. Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables. **Radiation Physics:** Radiation units exposure, absorbed dose, units: rad, gray,relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation	20

	Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid State detectors, TFT.	
3	**Medical Imaging Physics**: Evolution of Medical Imaging, X-ray diagnosticsand imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). (9 Lectures) **Radiation Oncology Physics**: External Beam Therapy (Basic Idea):Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy- LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.	20
4	**Radiation and Radiation Protection:** Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose. **Physics of Diagnostic and Therapeutic Systems-II:** Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment.	15

	Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.	

TEXT BOOKS

- Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
- Basic Radiological Physics Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- Physics of the human body, Irving P. Herman, Springer (2007).
- Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3 rd edition (2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
- The Physics of Radiology-H E Johns and Cunningham.

Astronomy and Astrophysics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Astronomy and Astrophysics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week:
6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours:
75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 604 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course:</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Astronomical scalar and concepts of positional astronomy, Astronomical techniques for making measurements, Basics of solar and stellar physics, Milky Way and Galaxies – introductory knowledge and Large scale structures and expending universe.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Skills to learn and operate astronomical instruments to perform observations related to the positional astronomy measurement.
Conceptualize skills to understand basic parameters for describing the properties of stars and making experimental measurements, their interpretation and role in understanding of astrophysical phenomenon. Study of solar and stellar spectra.
Learn to describe solar parameters, solar atmosphere, origin of solar system, solar and extra-solar planets, planetary rings.
Acquire basic knowledge of Milky Way and Galaxies, their properties and structure.
Skills for understanding basics of large scale structures and expending universe.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Ability to comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and measurement of distances, time and temperature and radius of star.
Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram</td></tr>
</table>

	● Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes. ● Understanding Physics of sun and solar system: photosphere, chromosphere, corona, solar activity. Solar MHD, helioseismology, solar system and its origin. Nebular model. ● Tidal forces and planetary rings. ● Understanding Physics of stars and sun. Role of gravitation in astroPhysics, Newton vs Einstein, viral theorem and thermodynamic equilibrium. Atomic spectra, stellar spectra. ● Spectral classification, luminosity classification, temperature dependence. ● Acquire basic knowledge of galaxies and Milky Way. Morphology and classification of galaxies, intrinsic stages of galaxies, galactic halo, milky way, gas and dust in galaxy, spiral arm, rotation of galaxy and dark matter. Star clusters in Milky Way, galactic nucleus and its properties.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Astronomical Scales:** Astronomical Distance, Mass and Time, Scales, Brightness,Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.	20
2	**Astronomical techniques:** Basic Optical Definitions for Astronomy (MagnificationLight Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).	25

	Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium. **The sun** (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere.Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: TheNebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **Stellar spectra and classification Structure** (Atomic Spectra Revisited, Stellar Spectra,Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)	
3	**The milky way** : Basic Structure and Properties of the Milky Way, Nature of Rotation ofthe Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.	15
4	**Galaxies**: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms. **Large scale structure & expanding universe**: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).	15

TEXT BOOKS

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Private limited, New Delhi,2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Embedded systems- Introduction to Microcontroller

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Embedded systems- Introduction to Microcontroller</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 6</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 604 DS 5106</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 150)</td><td>CIE</td><td>45 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>105 Marks</td><td colspan="3">Prerequisite of Course: Basic Electronics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Embedded Systems Intel microprocessor 8085, Intel 8051 microcontroller, architecture, instruction set, programming and its memory organization, timing diagram, Input/output operations and manipulation for arithmetic and logical operations, Programming with and without interrupt service request, Interfacing parallel and serial ADC and DAC, Embedded system development and product development</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn the architecture of embedded systems, their classification and application.
● Learn about the microprocessors and the organization of microprocessor based systems.
● Acquire knowledge of microcontrollers and their role in 1/0 port programming and their interface with peripherals.
● Learn about analog to digital and digital to analog convertors.
● Learn basics of Arduino and programming.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the successful completion of the course the student is expected to master the following:
● Embedded systems including its generic architecture, design and classifications,
● Embedded processors and microcontrollers.
● Organization of intel microprocessor 8085, its architecture, pin diagram, timing diagram, instruction set and programming in assembly language.
● Organization of Intel 8051 microcontroller, its architecture, instruction set, programming and its memory organization, timing diagram.</td></tr>
</table>

	• Input/output operations and manipulation for arithmetic and logical operations.	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Embedded system introduction**: Introduction to embedded systems and generalpurpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers. **Review of microprocessors:** Organization of Microprocessor based system, 8085µp pindiagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **8051 microcontroller**: Introduction and block diagram of 8051 microcontroller,architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) registr, Jump, loop and call instructions.	20
2	**8051 I/O port programming**: Introduction of I/O port programming, pin out diagram of8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. **Programming**: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.	20
3	**Timer and counter programming**: Programming 8051 timers, counter programming. **Serial port programming with and without interrupt**: Introduction to 8051 interrupts, programming timer interrupts, programming external	17

	hardware interrupts and serial communication interrupt, interrupt priority in the 8051. **Interfacing 8051 microcontroller to peripherals**: Parallel and serial ADC, DAC interfacing, LCD interfacing.	
4	**Programming Embedded Systems**: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **Embedded system design and development:** Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. **Introduction to Arduino:** Pin diagram and description of Arduino UNO. Basic programming	18

TEXT BOOKS

- Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008,Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G.
- Mazidi, and R.D. McKinlay, 2 nd Ed., 2007, Pearson Education India.
- Embedded microcomputer system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
- Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
- Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, C engage Learning

SEC PAPERS

Physics Workshop Skills

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Physics Workshop Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 101 SE 0042</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at introducing to make simple length, height, time, area, volume measurements, mechanical skills needed to the workshop practice, Electrical and electronics skills related to the measurement of various electrical and electronics quantities.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn to use mechanical tools to make simple measurement of length, height, time, area and volume.
● Obtain hand on experience of workshop practice by doing casting, foundry, machining, welding and learn to use various machine tool like lathe shaper, milling and drilling machines etc. and working with wooden and metal blocks.
● Learn to use various instruments for making electrical and electronics measurements using multimeter, oscilloscopes, power supply, electronic switches and relays.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the successful completion of the course the student is expected to acquire skills/ hands on experience / working knowledge on various machine tools, lathes, shapers, drilling machines, cutting tools, welding sets and also in different gear systems, pulleys etc. He /she will also acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction:** Measuring units. conversion to SI and CGS. Familiarization with meterscale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.	12
2	**Mechanical Skill:** Concept of workshop practice. Overview of manufacturing methods:casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.	18
3	**Electrical and Electronic Skill:** Use of Multimeter. Soldering of electrical circuitshaving discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.	18
4	**Introduction to prime movers:** Mechanism, gear system, wheel, Fixing of gears withmotor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.	12

TEXT BOOKS

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

Renewable Energy and Energy Harvesting

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Renewable Energy and Energy Harvesting</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours: 30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 102 SE 2002</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Fossil fuels and Alternate Sources of Energy, Solar energy, Wind Energy harvesting, Ocean Energy, Geothermal Energy, Hydro Energy, Piezoelectric Energy Harvesting, and Electromagnetic Energy Harvesting.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible.
In this course student will study non –conventional energy sources and their practical applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">The students are expected to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.
Learn about piezoelectricity, carbon- captured technologies like cells, batteries.
The students should observe practical demonstrations of (i) training modules of solar energy, wind energy etc., (ii) Conversion of vibration into voltage using piezoelectric materials, (iv) conversion of thermal energy into voltage using thermoelectric modules.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional</td><td>8</td></tr>
</table>

	energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **Solar energy:** Solar energy, its importance, storage of solar energy, solar pond, nonconvective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	
2	**Wind Energy harvesting:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **Ocean Energy:** Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	8
3	**Geothermal Energy:** Geothermal Resources, Geothermal Technologies. Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.	7
4	**Piezoelectric Energy harvesting:** Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric Energy harvesting applications, Human power. **Electromagnetic Energy Harvesting:** Linear generators, physics mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.	7

TEXT BOOKS

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

Computational Physics Skills

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2022-27	Computational Physics Skills	0	0	4	2	IV	Total Hours: 60
Subject Code: SBS PHY 03 201 SE 0042	Applicable to Program: Integrated B.Sc. M.Sc. (Physics)	Evaluation (Total Marks: 50)	CIE	15 Marks	Examination Duration: 3 hours (Practical)		
			TEE	35 Marks	Prerequisite of Course: None		

#	Contents	Hours
1	**Introduction:** Importance of computers in Physics, the paradigm for solving physics problems for solution. Usage of Linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (i) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **Scientific Programming:** Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character, and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.	20

2	**Control Statements:** Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DOWHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.	20
3	**Scientific word processing:** Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.	10
4	**Visualization:** Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user-defined variables and functions), Understanding data with Gnuplot	10

TEXT BOOKS

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, AddisonWesley, 1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.

- Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
- A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed., 2007, Wiley India Edition.

Programming Exercises:

1. Exercises on syntax on the usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all-natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

Hands-on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation, etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write a program to open a file and generate data for plotting using Gnuplot.
6. Plotting the trajectory of a projectile projected horizontally.
7. Plotting the trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of the equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of a particle in a central force field and plot the output for visualization.

Applied Optics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Mechanical Drawing</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 202 SE 0042</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Sources and Detectors, Fourier Optics, Holography and Photonics: Fibre Optics</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course will help in understanding about the lasers and detectors, Holography, Optical fibre and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">This course will enable the student to get:
● Familiar with optical phenomena and technology.
● Qualitative understanding of basic lasing mechanism, types of Lasers, characteristics of Laser Light, types of Lasers, and its applications in developing LED, Holography.
● The idea of propagation of electromagnetic wave in a nonlinear media – Fibre optics as an example will enable the student to practice thinking in a logical process, which is essential in science.
● Experiments in this course will allow the students to discuss in peer groups to develop their cooperative skills and reinforce their understanding of concepts.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Sources and Detectors** Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers. **Experiments on Lasers:** a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser. b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser. c. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser **Experiments on Semiconductor Sources and Detectors:** a. V-I characteristics of LED b. Study the characteristics of solid state laser c. Study the characteristics of LDR d. Photovoltaic Cell e. Characteristics of IR sensor	15
2	**Fourier Optics** Concept of Spatial frequency filtering, Fourier transforming property of a thin lens **Experiments on Fourier Optics:** **a. Fourier optic and image processing** 1. Optical image addition/subtraction 2. Optical image differentiation 3. Fourier optical filtering 4. Construction of an optical 4f system **b. Fourier Transform Spectroscopy** Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science. **Experiment:** 1. To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the	15

	transmission characteristics of several interference filters. Computer simulation can also be done.	
3	**Holography** Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition **Experiments on Holography and interferometry:** 1. Recording and reconstructing holograms 2. Constructing a Michelson interferometer or a Fabry Perot interferometer 3. Measuring the refractive index of air 4. Constructing a Sagnac interferometer 5. Constructing a Mach-Zehnder interferometer 6. White light Hologram	15
4	**Photonics: Fibre Optics** Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating **Experiments on Photonics: Fibre Optics** a. To measure the numerical aperture of an optical fibre b. To study the variation of the bending loss in a multimode fibre c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern d. To measure the near field intensity profile of a fibre and study its refractive index profile e. To determine the power loss at a splice between two multimode fibre	15

TEXT BOOKS

- Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
- ASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
- Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
- Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

Basic Instrumentation Skills

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject: Basic Instrumentation Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS SBS PHY 03 301 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Develop skills to use basic electrical instruments like multimeter, electronic voltmeter, cathode ray, and oscilloscope.
● Acquire efficiency in making signal generators and analysis of obtained signals.
● Learn to understand and use various types of digital instruments.
● Develop knowledge of making measurements with Impedance Bridges and Q meters.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the successful completion of the course the student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements. He/she will acquire hands on skills in the usage of oscilloscopes, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes. He/she also would have gained knowledge on the working and operations of LCR Bridge, generators, digital meters and counters.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC milli voltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.	15
2	**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.	15
3	**Signal Generators and Analysis Instruments:** Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **Impedance Bridges & Q-Meters:** Block diagram of bridge. working principles of basic(balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.	15
4	**Digital Instruments:** Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **Digital Multimeter:** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period	15

	measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.	

TEXT BOOKS

- Text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

The test of lab skills will be of the following test items:
1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:
1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:
1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Weather Forecasting

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Weather Forecasting</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
V</td><td>Contact Hours per Week:
2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours:
30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 302 SE 2002</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting technique.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of classical mechanics
● To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
● To aware the students about applications of classical mechanics in various science
branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
● To learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
● Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall. Absorption, emission and scattering of radiations in atmosphere. Radiation laws.
● Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.</td></tr>
</table>

	• Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain. • Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction to atmosphere:** Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.	8
2	**Measuring the weathe**r: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws. **Weather systems**: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.	8
3	**Climate and Climate Change**: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.	7
4	**Basics of weather forecastin**g: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.	7

TEXT BOOKS

- Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
- The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
- Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
- Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
- Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.
- Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

LIST OF DEMONSTRATIONS AND EXPERIMENTS

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
(a) To calculate the sunniest time of the year.
(b) To study the variation of rainfall amount and intensity by wind direction.
(c) To observe the sunniest/driest day of the week.
(d) To examine the maximum and minimum temperature throughout the year.
(e) To evaluate the relative humidity of the day.
(f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

Electrical Circuits and Network Skills

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject: Electrical Circuits and Network Skills</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week: 2</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 401 SE 0042</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory only)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Design and troubleshoot the electrical circuits, networks and appliances through hands on mode.
Build the basic foundation for learning electrical wirings and repairing of other house hold equipment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
Design and troubleshoot certain electrical circuits and domestic appliances along with the understanding of the working of those appliances.
Do electrical wiring and repairing.
This knowledge will develop the skill of the students for various electrical repairing and servicing purposes.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC</td><td>8</td></tr>
</table>

	Electricity and DC, Electricity. Familiarization with multimeter, voltmeter and ammeter **Understanding Electrical Circuits:** Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money	
2	**Electrical Drawing and Symbols:** Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **Generators and Transformers:** DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.	8
3	**Electric Motors:** Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heater and motors, speed and power of ac motor. **Solid state devices:** Resistors, inductors and capacitors, Diode and rectifiers, Components in series or in shunt, Response of Inductors and capacitors with AC or DC sources.	7
4	**Electrical Protections:** Relays, fuses and disconnect switches, Circuit breakers, Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **Electrical Wiring:** Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.	7

TEXT BOOKS

- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBS Edn.

Radiation Safety

Scheme Version: 2022-27	**Name of the subject:** Radiation Safety	**L**	**T**	**P**	**C**	**Semester: VI**	**Contact Hours per Week:** 2
		2	0	0	2		**Total Hours:** 30
Subject Code: SBS PHY 03 402 SE 2002	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 50)**	**CIE**	15 Marks	**Examination Duration:** 3 hours		
			TEE	35 Marks	**Prerequisite of Course:** None		
Course Description	This course aims at providing knowledge of Basics of Atomic and Nuclear Physics, Interaction of Radiation with matter: Types of Radiation, Radiation detection and monitoring devices: Radiation Quantities and Units, Radiation safety managemens, Application of nuclear techniques.						
Course Objectives	● General concepts of nuclei, nuclear forces and atomic physics are studied. ● Basic knowledge about nuclear radiation types and radiation detectors.						
Course Outcomes	● Be aware and understand the hazards of radiation and the safety measures to guard against these hazards. ● Revise or learn the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus. ● Have a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials. ● Know about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.						
COURSE SYLLABUS							
Unit No.	**Content of Each Unit**						**Hours of Each Unit**

1	**Basics of Atomic and Nuclear Physics**: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.	7
2	**Interaction of Radiation with matter:** Types of Radiation: Alpha, Beta, Gamma andNeutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.	7
3	**Radiation detection and monitoring devices**: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire ProportionalCounters (MWPC) and Gieger Muller Counter), Scintillation Detectors(Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.	8
4	**Radiation safety management**: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. **Application of nuclear techniques:** Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial	8

	Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.	

TEXT BOOKS

- W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)
- G.F.Knoll, Radiation detection and measurements
- Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
- W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.
- J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
- Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
- A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981

GE PAPERS [Physics]

Mechanics [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Mechanics [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 101 GE 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce elementary concepts of Mechanics to the students so that they are able to understand fundamental aspects of forces, nature of forces and their applications. Objective here is that with the comparatively advanced mathematics tools than their high school curriculum, they will be able to apply these concepts in other branches of Physics and Science in general.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of Physics
● To get familiar with various concepts of mechanical problems related to Gravitational Force, spring force and oscillations.
● To inform the students about applications of mechanics in other science branches.
● To have a clear understanding about concepts related to space, time and relative motion.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the fundamentals of dynamics in constant as well as variable mass systems
● Learn about various concepts related to rotational dynamics and elasticity.
● Learn about gravitational force and spring force
● Understand the basic inception of space and time, and relative motion in inertial as well as non-inertial frames.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **Ordinary Differential Equations:** 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **Laws of Motion:** Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.	18
2	**Rotational Motion:** Angular velocity and angular momentum. Torque. Conservation of angular momentum. **Gravitation:** Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.	15
3	**Oscillations:** Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **Elasticity:** Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method.	15
4	**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.	12

TEXT BOOKS
● University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley ● Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill. ● Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley ● Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press ● University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Note: Students may not be familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Mechanics Laboratory [GE]

Scheme Version: 2022-27	**Name of the subject:** Mechanics Laboratory [GE]	**L**	**T**	**P**	**C**	**Semester: I**	**Contact Hours per Week:** 4
		0	0	4	2		**Total Hours:** 60
Subject Code: SBS PHY 03 102 GE 0044	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 50)**	**CIE**	15 Marks	**Examination Duration:** 3 hours (Practical)		
			TEE	35 Marks	**Prerequisite of Course:** None		

#	List of Experiments	Hours
1	1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope. 2. To determine the Height of a Building using a Sextant. 3. To determine the Moment of Inertia of a Flywheel. 4. To determine the Young's Modulus of a Wire by Optical Lever Method. 5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.	60

	6. To determine the Elastic Constants of a Wire by Searle's method. 7. To determine g by Bar Pendulum. 8. To determine g by Kater's Pendulum. 9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Electricity and Magnetism [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Electricity and Magnetism [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 201 GE 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Electricity and Magnetism which covers the topics of Electric Field and Electric Potential, Electrostatic energy of system of charges, Dielectric Properties of Matter, Magnetic Field, Magnetic Properties of Matter, Electromagnetic Induction, Electrical Circuits, Network Theorems and Ballistic Galvanometer</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● This course will help in understanding basic concepts of electricity and magnetism and their applications.
● Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, the student should be able to
● Demonstrate Coulomb’s law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
● Explain and differentiate the vector (electric fields, Coulomb’s law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
● Apply Gauss’s law of electrostatics to solve a variety of problems.
● Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Vector Analysis:** Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).	12
2	**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	18
3	**Magnetostatics:** Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. **Magnetic properties of materials:** Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.	15
4	**Electromagnetic Induction:** Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **Maxwell`s equations and Electromagnetic wave propagation:** Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.	15

TEXT BOOKS

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press

- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

Note: Students may not be familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Electricity and Magnetism Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Electricity and Magnetism Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 202 GE 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses. (e) Measurement of charge and current sensitivity and Measurement of CDR
2. Determine a high resistance by Leakage Method
3. To determine Self Inductance of a Coil by Rayleigh's Method.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
6. To study the Characteristics of a Series RC Circuit.
7. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor</td><td>60</td></tr>
</table>

	8. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q 9. To determine a Low Resistance by Carey Foster's Bridge. 10. To verify the Thevenin and Norton theorems 11. To verify the Superposition, and Maximum Power Transfer Theorems	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Waves and Optics [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Waves and Optics [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 301 GE 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to introduce the student to a broad range of physical phenomena involving waves (including mechanical waves, sound waves, and electromagnetic waves), coherence, interference and diffraction phenomena</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Learn the basics of wave motion.
● Know about the behavior of light due to its wave nature.
● Identify and understand different phenomena due to the interaction of light with light and matter.
● Analyze some of the fundamental laws and principles of light which is used in many important optical instruments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Enable the students to analyze different phenomena due to the interaction of light with light and matter.
● Train the students to use different optical instruments.
● Help the students to understand various natural phenomena using different apparatus in the laboratory.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Superposition of Two Collinear Harmonic oscillations:** Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **Superposition of Two Perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **Waves Motion- General:** Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.	15
2	**Fluids:** Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication. **Sound:** Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.	15
3	**Wave Optics:** Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **Interference:** Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **Michelson's Interferometer:** Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.	15
4	**Diffraction:** Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.(5 Lectures)	15

TEXT BOOKS
• Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill • Principles of Optics, B.K. Mathur, 1995, Gopal Printing • Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications • University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

Waves and Optics Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Waves and Optics Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: III</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 302 GE 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde’s Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light</td><td>60</td></tr>
</table>

	8. To determine the value of Cauchy Constants. 9. To determine the Resolving Power of a Prism. 10. To determine wavelength of sodium light using Fresnel Biprism. 11. To determine wavelength of sodium light using Newton's Rings. 12. To determine the wavelength of Laser light using Diffraction of Single Slit. 13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating 14. To determine the Resolving Power of a Plane Diffraction Grating. 15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Modern Physics [GE]

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject: Modern Physics [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 401 GE 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of One dimensional potential problem of bound states and scattering and elementary introduction of nuclear physics with emphasis on

(i) Nuclear Structure
(ii) Nuclear Forces
(iii) Nuclear Decays
(iv) Fission and Fusion</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To Comprehend the failure of classical physics and need for quantum physics.
● To Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.
● To Formulate the basic theoretical problems in one, two and three dimensional physics and solve them.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

● Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
● Understand the theory of quantum measurements, wave packets and uncertainty principle.
● Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques,</td></tr>
</table>

	skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier. ● Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	18
2	Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.	12
3	One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potentialbarrier. Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.	15
4	Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half life α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor:	15

	slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.	

TEXT BOOKS

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
- Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning
- Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

Modern Physics Laboratory [GE]

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Modern Physics Laboratory [GE]</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IV</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 402 GE 0044</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration:
3 hours (Practical)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">1. Measurement of Planck’s constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum
energy of photo-electrons versus frequency of light</td><td>60</td></tr>
</table>

	3. To determine work function of material of filament of directly heated vacuum diode. 4. To determine the Planck's constant using LEDs of at least 4 different colours. 5. To determine the wavelength of H-alpha emission line of Hydrogen atom. 6. To determine the ionization potential of mercury. 7. To determine the absorption lines in the rotational spectrum of Iodine vapour. 8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet. 9. To setup the Millikan oil drop apparatus and determine the charge of an electron. 10. To show the tunneling effect in tunnel diode using I-V characteristics. 11. To determine the wavelength of laser source using diffraction of single slit. 12. To determine the wavelength of laser source using diffraction of double slits. 13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.	

TEXT BOOKS

- Arora, C.L. 2015. B.Sc. Practical Physics. II Edition. New Delhi: S. Chand & Co.
- Panigrahi, S. and Mallick, B. 2015. Engineering Practical Physics. I Edition. New Delhi: Cengage Learning India.
- Prakash, I. and Ramakrishna. 2011. A Text Book of Practical Physics. I Edition. New Delhi: Kitab Mahal.

Ability Enhancement Compulsory Courses (AECC)

English Communication

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:

English Communication</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS ENG 0207 AECC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction**: Theory of Communication, Types and modes of Communication **Language of Communication**: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication	18
2	**Speaking Skills**: Monologue Dialogue Group Discussion Effective Communication/ Mis- Communication Interview Public Speech	14
3	**Reading and Understanding** Close Reading Comprehension Summary Paraphrasing Analysis and Interpretation Translation(from Indian language to English and vice-versa)	14

	Literary/Knowledge Texts	
4	**Writing Skills** Documenting Report Writing Making notes Letter writing	14
TEXT BOOKS		
1. *Fluency in English* - Part II, Oxford University Press, 2006. 2. *Business English*, Pearson, 2008. *3. Language, Literature and Creativity*, Orient Blackswan, 2013. 4. *Language through Literature* (forthcoming) ed. Dr. Gauri Mishra, Dr. Ranjana Kaul, Dr Brati Biswas		

Environmental Sciences

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:

Environmental Sciences</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS EVS 0107 AECC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction to Environmental Sciences:** Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.	15
2	**Ecosystem: I**ntroduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem :- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems	15
3	**Biodiversity and its conservation**: Introduction – Definition, value and types: genetic, species and ecosystem diversity. Bio-geographical classification and Hot-spots of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation.	15
4	**Environmental issues and policies:** Definition, cause, effects and control measures of Air, Water, Soil, Marine and Noise pollution.	15

	Solid Waste Management: Causes, effects and control measures of wastes. Seventeen Sustainable Developmental Goals, Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, Public awareness.	

TEXT BOOKS

1. Bharucha E, (2002) The Biodiversity of India, Mapin Publishing
2. Cao G, Orru R (2014) Current Environmental Issues and Challenges. 2014th edition; Springer
3. Cunningham W P, Cunningham M A (2008) Principles of Environment Science. Enquiry and Applications. 5th Edition. Tata McGraw Hill, New Delhi
4. Dash M C, Dash S P (2009) Fundamentals of Ecology. 3rd McGraw Hill Education
5. Gibbs J, Malcolm L, Sterling J (2008) Problem-Solving in Conservation Biology and Wildlife Management. 2nd ed. Wiley-Blackwell
6. Ginley D, Cahen, D (2011) Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press
7. Gilbert M (2007) An Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi
8. Khan I (2019) Forest Governance and Sustainable Resource Management. SAGE Publications. India.
9. Odum E P, Barrett W, (2005) Fundamentals of Ecology. 5th ed. Cengage Learning.
10. Sharma P D (2017) Ecology and Environment. 13th ed. Rastogi Publications
11. Thangadurai D, Ching G, Jeyabalan S, Islam S (2019) Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. United States: Apple Academic Press
12. Trivedi R K (2010) Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards, 3rd Edition. BS Publications

प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)
Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)

माध्यमः – संस्कृत/हिन्दी/आंग्लभाषा
Medium – Sanskrit/Hindi/English

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:

प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)

Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: I/II</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS SKT 0209 AECC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Obejctive</td><td colspan="7">1. संस्कृतेतर-विषयाणामध्येतृभ्यः संस्कृताध्ययनाय सौकर्योत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां वेदादि-शास्त्राणामुपनिषदां च रुचिरुत्पादनम्; 3. संस्कृतेनोपनिबद्धानां नीतिवाक्यानां गीतायां वर्णितस्य कर्मयोगस्य च तत्त्व-संधारणाय यत्नः; 4. सामान्य-भाषाविज्ञानस्य परिचयः।</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● अध्येतारः वेदादि-शास्त्राणामुपनिषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नशीलाः भवेयुः।
● व्यावहारिकदृष्ट्या संस्कृतज्ञानेन अन्यविषयाणामध्येतारः तत्तद् स्वविषयानुगुणं संस्कृतभाषायामुप- लभ्यमानानां ग्रन्थानां प्रति यत्नशीलाः स्युः।
● वेदोपनिषत्–गीता–नीतिशास्त्र–भाषाशास्त्रादीनां विषयाणां सम्यगध्ययनेनास्माकं पूर्वजानां वैदुष्येण परिचयः संजायेत।
● भारतीय-चिन्तनपरम्परायाः समृद्धिं ज्ञातुमयं पाठ्यक्रमः प्रकृष्टमाध्यमः संजायेत।</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)	15
2	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः	15
3	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भगवद्गीता – तृतीयाध्यायः (कर्मयोगः)	15
4	मन्त्राणां सन्दर्भानां श्लोकानां च व्याख्या सारसंक्षेपश्च – सामान्यभाषाविज्ञानम्- (क) वर्णमाला, वर्णानाम् उच्चारणस्थानानि प्रयत्नाश्च; (ख) भाषाविज्ञानस्य सामान्य परिचयः, भाषापरिवर्तनस्य कारणानि, अर्थपरिवर्तनस्य कारणानि च	15

TEXT BOOKS /अनुशंसितग्रन्थाः

1. उवव्ट-महीधर, शुक्लयजुर्वेदभाष्य, मोतीलाल बनारसीदास, दिल्ली, 2007
2. स्वामी दयानन्द सरस्वती, यजुर्वेदभाष्य, सम्पा० ब्रहमदत्त जिज्ञासु, रामलाल कपूर ट्रस्ट, सोनीपत (हरियाणा)
3. तैत्तिरीयोपनिषद्, हिन्दी व्याख्याकार - स्वामी प्रखर प्रज्ञानन्द सरस्वती, काशी, 2013
4. भर्तृहरि, नीतिशतक, सम्पादक एवं हिन्दी व्याख्याकार - जनार्दन शास्त्री पाण्डेय, मोतीलाल बनारसीदास, दिल्ली, 2014
5. नीतिशतकम्, 'नीतिपथ' हिन्दी व्याख्याकार - राजेश्वर शास्त्री मुसलगाँवकर, चौखम्भा, वाराणसी
6. श्रीमद्भगवद्गीता (हिन्दी अनुवाद सहित), गीता प्रैस, गोरखपुर, 2015
7. श्रीकृष्ण त्रिपाठी, श्रीमद्भगवद्गीता (द्वितीय, तृतीय एवं चतुर्थ अध्याय), 2005
8. देवीदत्त शर्मा, भाषिकी और संस्कृत भाषा, हरियाणा साहित्य अकादमी, चण्डीगढ़, 1990
9. कपिलदेव द्विवेदी, भाषा-विज्ञान एवं भाषा-शास्त्र, विश्वविद्यालय प्रकाशन, चौक, वाराणसी, 2012
10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ
11. Burrow, T., The Sanskrit Language, 2016
12. Gune, P.D., An Introduction to Comparative Philology, Oriental Book House, Poona, 1958
13. The Taittirīya Upaniṣad, Eng. Tr. and Commentary by Swami Muni Narayana Prasad, D.k. Print world (P), Ltd., New Delhi-2009
14. The Nīti and Vairāgya Śatakas of Bhartrihari, M.R. Kale, Motilal Banarsidass, Delhi, 2017

हिंदी भाषा: रचना एवं व्यवहार

Scheme Version: 2022-27	**Name of the subject:** हिंदी भाषा: रचना एवं व्यवहार	**L**	**T**	**P**	**C**	**Semester:** I/II	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours:** 60
Subject Code: SBS PHY 03 203 AE 4004	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Obejctive	भाषा, व्याकरण एवं साहित्य के सामान्य स्वरूप का हिदर्शि ।						
Course Outcomes	• भाषा, बोली और व्याकरण के विविध घटकों का परिचय । • संचार माध्यमों के स्वरूप और भाषा का ज्ञान । • रचना पाठ से साहित्य बोध ।						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Unit–I भाषा और व्याकरण** भाषा की परिभाषा एवं विशेषताएं भाषा और व्याकरण हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)	15

2	**Unit –II हिंदी की संवैधानिक स्थिति** हिंदी भाषा व बोलियों का संक्षिप्त परिचय हिंदी की संवैधानिक स्थिति : राजभाषा, संपर्क भाषा और राष्ट्रभाषा कार्यालयी हिंदी : पल्लवन, संक्षेपण, टिप्पण पत्र लेखन : सरकारी, अर्द्ध-सरकारी	15
3	**Unit –III संचार माध्यमों का स्वरूप एवं भाषा** संचार माध्यमों का स्वरूप एवं भाषा संचार माध्यमों का सामाजिक प्रभाव कंप्यूटर में हिंदी का अनुप्रयोग	15
4	**Unit -IV** **कहानी : चंद्रधर शर्मा 'गुलेरी' :** उसने कहा था; **प्रेमचंद :** नशा **निबंध : हजारी प्रसाद द्विवेदी :** नाखून क्यों बढ़ते हैं; **बालमुकुंद गुप्त :** बनाम लार्ड कर्जन **कविता : सूर्यकांत त्रिपाठी 'निराला' :** वर दे, वीणा वादिनी वर दे ! **जयशंकर प्रसाद :** हिमाद्रि तुंग शृंग से	15

TEXT BOOKS /अनुशंसितग्रन्थाः

1. हिंदी : उद्भव, विकास और रूप; डॉ हरदेव बाहरी; किताब महल इलाहाबाद; 1969.
2. हिंदी भाषा; डॉ भोलानाथ तिवारी; किताब महल, इलाहाबाद; 2004.
3. हिंदी व्याकरण; कामता प्रसाद गुप्त; नागरी प्रचारिणी सभा, काशी; 1927.
4. व्यावहारिक हिंदी व्याकरण तथा रचना; हरदेव बाहरी; लोकभारती प्रकाशन, इलाहाबाद; 1972.
5. कंप्यूटर और हिंदी; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2015.
6. रेडियो और दूरदर्शन पत्रकारिता; हरिमोहन; तक्षशिला प्रकाशन, दिल्ली; 2017.

Course Contents

(for Semester VII to X)

Core Courses

Classical Mechanics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Classical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 701 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basic knowledge of mechanics and calculus</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Classical Mechanics to the students so that they are able to understand the Lagrangian & Hamiltonian mechanics of systems of particles interacting with various forces and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of classical mechanics
● To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
● To aware the students about applications of classical mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the mechanics of system of particles, D’Alembert’s principle, Lagrangian mechanics, & Euler’s equation of motion.
● Learn about Hamiltonian formulation, Hamilton’s Equations of Motion and Principle of least action.
● Learn Canonical Transformations & Hamilton-Jacobi theory.
● Learn about Rigid body dynamics including problems.
● Understand the two body central force problem and its related aspects.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Lagrangian Formulation and Central Force Problem:** Newtonian mechanics of one and many particle systems,Virtual work, Constraints: holonomic and non-holonomic,D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton's Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem. The Kepler Problem.	15
2	**Hamilton's Equations of Motion:** Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.	15
3	**Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variables, Adiabatic invariance of action variable, Applications of action angle variables: The Kepler problem	15
4	**Small Oscillations and Rigid Body Motion:** Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator. Orthogonal transformation, Eigenvalues of the inertia tensor, Euler equations, Eulerian angles, moment of Inertia. Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Coriolis force. Perturbation theory. Introduction to chaotic dynamics.	15

TEXT BOOKS

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- A.Sommerfeld, Mechanics, Academic Press,United States, 1st Edition, 1952.
- I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1982.
- Ronald L. Greene, Classical Mechanics with Maple, Springer,Germany, 2nd Edition, 2000.
- N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1st Edition, 2015.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

Advanced Mathematical Physics

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Advanced Mathematical Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 702 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Undergraduate level Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge Linear Vector Spaces, Matrices, Cartesian Tensors, General Tensors and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● In this course, the students should the learn the skills of doing calculations with the linear vector space, matrices, their eigenvalues and eigenvectors, tensors, real and complex fields, linear and multilinear transformations in various physical situations, e.g., the Lorentz transformations etc.
● They also become efficient in doing calculations with the ‘calculus of variation’.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
● Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g, operators in quantum mechanics. They should also learn how to find eigenvalues and eigenvectors of matrices.
● Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor, etc.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Linear Vector Spaces:** Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.	12
2	**Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product. Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix	18
3	**Cartesian Tensors:** Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.	18

4	**General Tensors:** Transformation of Coordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Metric Tensor.	12

TEXT BOOKS

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicists & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence,3rd Ed., 2006, Cambridge University Press

Advanced Quantum Mechanics

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Advanced Mathematical Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week:
4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 703 CC 4004</td><td rowspan="2">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Undergraduate level Mathematical Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand some advanced topics such as symmetries, identical particles, approximation methods and relativity in quantum mechanics, which has broad and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To make familiar with various advanced topics of quantum mechanics such as symmetries and conservation laws, fermions and bosons, time independent and time dependent perturbation theories, variational and WKB methods, scattering theory, delta function and relativistic theory
● To aware the students about applications of advanced phenomena of quantum mechanics in physical, mathematical and chemical sciences</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students will be able to
● understand the concepts of symmetries, conservation laws, bosons and fermions in quantum mechanics
● apply symmetries and conservation laws in various quantum mechanical problems
● illustrate the time independent and time dependent perturbation theories, the variational and WKB methods
● describe the fine structure and Zeeman effect phenomena
● explain the basics of scattering theory
● apply the delta function’s properties in various quantum mechanical problems
● understand the basics of relativistic quantum mechanics</td></tr>
</table>

	● recognize the importance and applications of relativistic quantum mechanics determine the transmission and reflection coefficients of potential barrier and well, potential step, and delta function well ● recognize the importance of angular momentum and its applications in quantum mechanics ● explain the physics behind the addition of angular momenta

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Structure of Quantum Mechanics:** Notion of state vector. Probability interpretation. Operators and observables, operators as matrices, significance of eigenvalues and eigenfunctions. Commutation relations. Measurement in quantum theory. **Symmetry and Angular momentum Algebra:** Symmetry operations and unitary transformations. Conservation laws. Space and time translations; rotation. Discrete symmetries: Space inversion, time reversal and charge conjugation. Symmetry and degeneracy. Rotation operator, generators of infinitesimal rotation, angular momentum algebra, eigenvalues of J^2 and J_z. Pauli matrices and spinors. Addition of angular momenta. Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Slater determinants, Pauli exclusion principle.	18
2	**Time-independent Approximation Methods:** Non-degenerate and degenerate perturbation theory. Stark effect, Zeeman effect and other examples. Variational methods. WKB approximation. Tunneling. Numerical perturbation theory, comparison with analytical results.	15
3	**Time-dependent Problems:** Schrödinger and Heisenberg pictures. Time-dependent perturbation theory. Transition probability calculations, Fermi's golden rule. Adiabatic and sudden approximations. Introduction to the quantization of electromagnetic field.	15
4	**Relativistic Quantum Mechanics:** Klein-Gordon equation, Dirac equation, Probability and Current Density, Plane Wave Solutions, Symmetries of the Dirac equation, Dirac's Equation for a Central Potential, Covariance of Dirac's Equation, Relativistic Hydrogen Atom Problem, The Hole Theory and Positrons. **Interaction:** Yukawa interaction, Coupling of electron and electromagnetic field, Feynman diagrams, Feynman rules, Path	12

	integration method: Probability amplitude as path integral, action, free particle and harmonic oscillator motion, Wick's Theorem. Scattering matrix.	

TEXT BOOKS

1. L. D. Landau and E.M. Lifshitz, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3rd Edition, 1981.
2. P. A. M. Dirac, The Principles of Quantum Mechanics, Oxford University Press, UK, 4th Edition, 1988.
3. R. Shankar, Principles of Quantum Mechanics, Springer, Germany, 2nd Edition, 1994.
4. N. Zettili, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2nd Edition, 2009.
5. J. J. Sakurai, Modern Quantum Mechanics, Pearson, India, 2nd Edition, 2013.
6. L. I. Schiff, Quantum Mechanics, McGraw Hill Education, USA, 4th Edition, 2017.
7. D. J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3rd Edition, 2018.
8. C. Cohen-Tannoudji, B. Diu, and F. Laloe, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2nd Edition, 2019.
9. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
10. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

Physics Laboratory-VII

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-VII</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VII</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 105 CC 00126</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the laboratory is to train students to perform various experiments associated with Electronics, Quantum physics, Waves mechanics and Spectroscopy. Students assigned the general laboratory work will perform at least ten (10) experiments of the above mentioned list of Physics experiments and further 8 experiments from the C programming section.. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To give hands-on experience to students for generating magnetic field and measurement of various parameters.
● To teach how temperature controlled oven works
● To take measurements of current and voltage using various equipment</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● learn various Physics aspects by performing the experiments related to electronic devices, atomic and molecular physics, light wave, sound waves etc.
● Learn Error analysis
● Use excel for plotting graphs
● to do C/C++ programming</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	1. Hall Effect 2. Four Probe Method to find band gap of semiconductor 3. Electron Spin Resonance 4. Frank-Hertz experiment 5. PN Junction characteristics 6. Solar cell characteristics 7. Velocity of ultrasonic wave in liquids 8. Characteristics of MOSFET 9. Diode as voltage regulator 10. Ionization potential of mercury 11. Planck's constant using LED 12. Law of Malus 13. Zener diode characteristics	150
2	Review of C/C++ Programming: 1. Write a Program to calculate and display the volume of a CUBE having its height, width and depth. 2. Write a C program to perform addition, subtraction, division and multiplication of two numbers 3. Write a program to input two numbers and display the maximum number. 4. Write a program to find the largest and smallest among three entered numbers and also display whether the identified largest/smallest number is even or odd. 5. Write a program to find the roots of quadratic equation. 6. Write a program to check whether the entered year is leap year or not (a year is leap if it is divisible by 4 and divisible by 100 or 400.) 7. Write a program to find the factorial of a number. 8. Write a program to check number is Armstrong or not. 9. Write a program to find GCD (greatest common divisor or HCF) and LCM (least common multiple) of two numbers 10. Write a program to generate Fibonacci series.	30
TEXT BOOKS		
1. Worsnop and Flint, Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951. 2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.		

Classical Electrodynamics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Classical Electrodynamics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 801 CC 4004</td><td rowspan="2">Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Undergraduate level Mathematical Physics and Electricity and Magnetism</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of basic electrodynamics and it's applications to various phenomena.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of classical electrodynamics and four-vector formalism
● To get familiar with various concepts used in retarded potential theory.
● To aware the students about modern problems in classical electrodynamics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● The students will have an understanding of boundary value problems in electrodynamics.
● The student will be able to learn the relativistic transformation of EM fields
● The students will be able to analyze radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate.
● The students will be able to learn advanced concepts of charge particle acceleration techniques.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Review of Electrostatics and Magnetostatics** Action-at-a distance vs. concept of fields, Poisson and Laplace equations and formal solution for scalar potential with Green's functions, boundary value problems; multipole expansion; Dielectrics, polarization of a medium; Clausius-Mossotti Relation, Electrostatic energy in dielectrics and Maxwell stress tensor, Magnetic multipole expansion of vector potential, Magnetization, Magnetostatic energy densities and Magnetic stress tensor	15
2	**Covariant Formulation of Electrodynamics** Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of **E** and **B**. Covariant formulation of Maxwell's equations, Equation of motion of charged particle, Motion of charged particles in external electric and magnetic fields.	15
3	**Electromagnetic Radiation:** Introduction to retarded potentials. Potentials due to a moving charge: Lienard Wiechert potentials. **E** and **B** due to a uniformly moving charge. **E** and **B** due to an accelerating charge particle: Power radiated, Larmor's formula and its relativistic generalization.	15
4	**Interaction of Matter with Charge Particles and Advanced Acceleration Techniques:** Radiation Bremsstrahlung and transition radiation, Thomson scattering, Synchrotron radiation and undulator radiation, Coherent emission from multiple particles, Coherence and Form factor, Radiation from relativistic particle traveling through matter: Cherenkov radiation	15

TEXT BOOKS

- Classical Electrodynamics, J D Jackson, Wiley; Third edition, 2003
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier
- Classical Electricity and Magnetism, W. K. H. Panofsky and M. Philips, Dover Publication, 2nd Edn, 2012
- Modern Problems in Classical Electrodynamics, Chales A Brau, OUP USA, 2003
- Classical Electrodynamics, S P Puri, Narosa Publishing; 2011
- Introduction to Electrodynamics, D.J. Griffiths, 2018, Fourth Edition, Pearson Education
- Feynman Lectures, Vol. II, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- X-Rays and Extreme Ultraviolet Radiation: Principles and Applications, David Attwood, Cambridge University Press; 2nd edition, 2017

Atomic and Molecular Physics

Scheme Version: 2022-27	Name of the subject: Atomic and Molecular Physics	L	T	P	C	Semester: VIII	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS PHY 03 802 CC 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	70 Marks	**Prerequisite of Course:** Modern Physics		
Course Description	Aim of the course is to aware students about various atomic and molecular spectra and to understand the working of LASERs.						
Course Objectives	The students will be exposed to . Rotation and Vibration spectroscopy . Raman Effect and Raman spectroscopy of molecules. . Working of Lasers						
Course Outcomes	On completion of the course, student would be able to : ● Understand different models of an Atom ● Derive the energy distribution corresponding to different levels of an atom ● Understand rotation spectroscopy and Understand Raman Effect and Raman spectroscopy of molecules. ● Understand the working of He-Ne Laser and Ruby Laser.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Atomic Spectra I: [Course Outcomes : CO301C.1]** Review of Atomic Models: Rutherford's Model, Bohr's model, Sommerfeld's model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect.	15
2	**Atomic Spectra II: [Course Outcomes : CO301C.2]**	15

	Spin-orbit interaction and fine structure, LS and JJ coupling, Relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the hydrogen atom spectra, Zeeman and Paschen-Back effect. Hyperfine structure and isotope shift, Auger Effect and Frank Condon Principle. Born-Oppenheimer approximation.	
3	**Molecular spectra: [Course Outcomes : CO301C.3]** Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, Vi vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy (Brief Introduction).	15
4	**Lasers: [Course Outcomes : CO301C.4]** Spontaneous and stimulated emission, Spatial and temporal Coherence, Einstein A and B coefficients, Optical Pumping, Population Inversion, Modes of resonator, Q-switching and Mode Locking, Ultra short pulse generation, He-Ne Laser and Ruby Laser-Principle, Construction and working, Application of lasers in the field of medicine and Industry.	15

Text Books

1. H. E. White, Introduction to Atomic Spectra, McGraw Hill, New York, 1st Edition, 1934.
2. H. G. Kuhn, Introduction to Atomic Spectra, Green and Co., Harlow, 2nd Edition, 1969.
3. K. Thyagarajan and A.K. Ghatak, Lasers - Theory and Applications, Plenum Press, New York, 1st Edition, 1981.
4. B. H.Bransden and C. J Joachain, Physics of Atoms and Molecules, Pearson, UK, 2nd Edition, 2003.
5. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, United States, 2nd Edition, 2006.
6. Arthur Beiser, Perspectives of Modern Physics, McGraw Hill, New York, 6th Edition, 2006.
7. C. N. Banwell, Fundamentals of Molecular Spectroscopy, McGraw Hill, New York, 4th Edition, 2017.

Nuclear Physics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Nuclear Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 803 CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course will enable the students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions. T</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Students will be exposed to
● General properties of nuclei
● Interactions among the nucleons
● Different models developed to explain the nuclear structure</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Understand basic properties of nuclei
● Understand interactions between nucleons, meson theory and spin dependence of nuclear forces
● Get knowledge about Nuclear models, Magic numbers, and Collective nuclear model.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Introductory Concept of Nuclei: Scattering and electromagnetic methods for determining the nuclear radius, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadrupole moment, Parity quantum number, Statistics of nuclear particles, Nuclear Disintegration: Simple</td><td>15</td></tr>
</table>

	theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.	
2	**Inter Nucleon Forces:** Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.	15
3	**Nuclear Structure and Models:** Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular moment, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi-empirical mass formula, Nuclear fission, The unified model.	15
4	**Heavy Ion Nuclear Reactions:** Total Hamiltonian function, Fusion fission dynamics, Radioactive ion beams, tightly and loosely bound interactions, Nuclear isomers, Nuclear Molecules, Nuclear Dynamics at Intermediate and high energies, Quantum Dynamics Models, Statistical Models, Multi-fragmentation, Elliptical Flow, Transverse Flow, Experimental Scenario, Relativistic heavy ion collisions	15

TEXT BOOKS

1. Roy & Nigam,Nuclear Physics, John Wiley & Sons, USA, 1st Edition, 1967.
2. H. Enge,Introduction to Nuclear Physics, Addison Wesley, USA, 1st Edition 1969.
3. J.M. Blatt and V.F. Weisskopf, Theoretical Nuclear Physics, Springer, Germany, 1st Edition, 1969.
4. M.Leon,Particle Physics:An introduction, Elsevier, Netherlands, 1st Edition, 1973.
5. S. N. Ghoshal, Nuclear Physics, S. Chand, India, 1st Edition, 1994.
6. F.I. Stancu, Group Theory in Subnuclear Physics, Clarendon Press, UK, 1st Edition, 1997.
7. J.D. Walecka,Theoretical Nuclear and Subnuclear Physics, World Scientific, Singapore, 2nd Edition, 2004.
8. B. R. Martin and G. Shaw,Particle Physics, John Wiley & Sons, USA, 3rd Edition, 2008.

Physics Laboratory-VIII

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-VIII</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (1^{st} Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 204 CC 00126</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim & objective of the course is to impart the practical training on various electronics devices such as; Op-Amp, Vibrators, Amplifiers, Michelson interferometer etc. Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To train students for various electronics experiments and take measurements
To train students on various optical instruments like Spectrometer, Michelson Interferometer
To have hand on experiment for measurement of magnetoresistance and dielectric constant.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
Understand spectral lines, grating spectra, and interference fringes
Learn the characteristics of Op-Amp, vibrators, clipper, clampers, and DA/ AD
Use excel for plotting graphs
Understand motion of temperature and magnetic field dependence of Hall coefficient.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Study of Balmer series and Rydberg constant 2. Op-Amp as inverting and non-inverting amplifier 3. Op-Amp as differentiator, Integrator and Adder 4. e/m by Thomson method 5. Single stage RC coupled amplifier 6. Frequency response of common emitter amplifier 7. Bistable/Monostable/Astable vibrators 8. Grating spectra 9. Refractive index of water and oil using prism 10. Magneto resistance 11. Temperature dependence of Hall coefficient 12. Digital to Analog converter, Analog to Digital converter 13. Michelson Interferometer 14. Faraday Effect 15. Clipper and clampers	150
2	1. Root finding of a polynomial equation using numerical methods 2. Solving first and second order differential equation numerical methods 3. Numerical integration 4. Generating finite and infinite series	30

TEXT BOOKS

1. Worsnop and Flint, Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951.
2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.
3. Lab manuals, prepared by faculty of the Department of Physics and Astrophysics, 2018.

Condensed Matter Physics

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject: Condensed Matter Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 901 CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Solid State Physics and Quantum Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">Solid state physics is the branch of physics dealing with physical properties of solids particularly crystals, including the behavior of electrons in these solids. The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.
● To develop the scientific and positive attitudes in students related to the materials science which is a part of solid state physics
● To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● identify various crystal structures and their symmetries in solids
● determine the crystal structure through X-ray diffraction, rotating crystal, and Laue methods
● explain the theories and phenomena of lattice dynamics, various bonding, and thermal properties (specifically specific heat) in solids
● calculate the specific heat and density of states of various solids</td></tr>
</table>

	● interpret the electrical conductivity and resistivity, mean free path, relaxation time, Fermi energy, electronic specific heat, and band formation in solids ● recognize the importance of effective mass, nearly free-electron model and tight binding approximation ● identify the basic differences between conductors and superconductors ● illustrate the some exciting phenomena such as Meissner effect, Isotope effect, London's equations, BCS theory, and Josephson effect of superconductors ● understand the basics of high temperature superconductors and commercial applications of superconductors	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Crystal Structure:** Crystal Structures and Lattices with Basis, Miller Indices, Common Crystal Structures, Reciprocal Lattice, Brillouin Zones, X-ray Diffraction by a Crystal and Their Equivalence, Laue Equations, Ewald Construction, Brillouin Interpretation, Intensity of X-ray Reflections: Atomic Scattering Factor; Geometrical Structure Factor, Structure Factors, Structure Factor; Experimental Methods of Structure Analysis: Laue's Method; Rotating Crystal Method; Powder Method, Diffraction from Non-Crystalline Systems.	15
2	**Lattice Dynamics, Crystal Binding and Thermal Properties:** Classical Theory of Lattice Dynamics: Vibrations of Crystals with Monatomic Basis and Two Atomic Basis; Dispersion Relation; Group Velocity; Acoustical and Optical modes, Bonding in Solids, Elastic Constants and Properties, Phonons: Quantization of Lattice Vibration; Phonon Momentum; Inelastic Scattering of Neutrons by Phonons, Thermal Properties: Heat Capacity; Density of States; Normal Modes; Debye and Einstein Models.	15
3	**Free Electrons and Energy Band in Solids:** Free Electron Gas Model and Its Limitations, Electrons Moving in One and Three Dimensional Potential Well, The Density of States, Fermi Energy, Effect of Temperature on Fermi Distribution Function, The Electronic Specific Heat, The Electrical Conductivity of Metals,	15

	Relaxation Time and Mean Free Path, The Electrical Resistivity, Band Theory:Bloch Theorem; The Kronig-Penny Model; Symmetry Properties of the Energy Function; Effective Mass of an Electron; The Nearly Free Electron Model and Tight Binding Approximation; Metals; Insulators and Semiconductors.	
4	**Superconductivity : I**ntroduction to Superconductivity, Effect of Magnetic Field, The Meissner Effect, Type I and Type II Superconductors, Entropy, Free Energy, Heat Capacity, Energy gap, Isotope Effect, Thermodynamics of the Superconducting Transition, London Equation and Penetration Depth, Coherence Length, BCS Theory of Superconductivity, Cooper Pair, Flux Quantization, DC and AC Josephson Effects: SQUIDs, High Temperature Superconductivity, Applications of Superconductors.	15

TEXT BOOKS

1. J. M. Ziman, Principles of the Theory of Solids, Cambridge University Press, UK, 2nd Edition, 1979.
2. J. F. Annett, Superconductivity Super fluids and Condensates, Oxford University Press, UK, 1st Edition, 2004.
3. J. P. Srivastava, Elements of Solid State Physics, Prentice-Hall of India, 2nd Edition, 2006.
4. H. Ibach and H. Luth, Solid State Physics: An Introduction to Theory and Experiment, Springer, Germany, 4th Edition, 2009.
5. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publications, India, 2nd Edition, 2009.
6. C. Kittel, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Holt, Rinehart and Winston, USA, Revised Edition, 2016.
8. S. O. Pillai, Solid State Physics, New Age International Publishers, 8th Edition, 2018.

Particle Physics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject: Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 902 CC 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours (Theory)</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Mathematical Physics, Quantum Physics and Nuclear Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart the knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● Students will understand the different type of particles and interactions among them
● Students will be able to understand the conservation laws in particle physics
● Students will get to know the production cross section for particles
● Students will understand the quark model.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Need of standard model and its limitations and the properties of QCD.
● Basic rules of Feynman diagrams and the quark model for hadrons
● Properties of neutrons and protons in terms of a simple quark model
● Weak interaction between quarks and how that this is responsible for β decay.
● Leptons and how the (electron) neutrinos and (electron) antineutrinos are produced during β+ and β- decays respectively</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Introduction:** Fermions and bosons, Particles and antiparticles, Quarks and leptons, Interactions and fields in particle physics, Classical and quantum pictures, Yukawa picture, Types of interactions - electromagnetic, weak, strong and gravitational, units.	15
2	**Invariance Principles and Conservation Laws:** Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem.	15
3	**Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy.	15
4	**Static Quark model of Hadrons:** The Eightfold way, Meson nonet, Baryon octet, Baryon Decuplet, hypothesis of quarks, SU (3) symmetry, Quark spin and color, Quark-antiquark combinations. **Weak Interactions:** Classification of weak interactions, Fermi theory, Weinberg-Salam model, Parity non-conservation in β-decay, Helicity of neutrino, Experimental verification of parity violation, K-decay.	15

TEXT BOOKS

1. Perkins, D.H., Introduction to High Energy Physics, Cambridge University Press, 2000, 3rd Ed.
2. Hughes, I.S., Elementary Particles, Cambridge University Press, 1991.
3. Close, F.E., Introduction to Quarks and Partons, Academic Press, 1979.
4. Segre, E., Nuclei and Particles, Benjamin-Cummings, 1977.
5. Khanna, M.P., Introduction to Particle Physics, Prentice-Hall of India, 2004.

Physics Laboratory-IX

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Physics Laboratory-IX</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 903 CC 00126</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of Lab III is to train students for advanced practical problems related to solid state physics, nuclear physics, electronics, numerical techniques and material science.

Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To train students on advanced experiments
● To give training on advance instruments
● To introduce students to latest numerical techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
● Do some experiments based on nuclear physics, electronics, computation and solid state physics.
● Understand the basic synthesis and characterization techniques for different materials such as thin films and nanoparticles.
● Perform advanced experiments like DTA, TGA, UV-VIS, Microwave furnace and thin film coating techniques.
● Learn advance techniques of numerical analysis</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Kerr Effect 2. Curie Temperature 3. B-H curve 4. Dielectric constant 5. Solid State Nuclear Track Detector (SSNTD) 6. G.M. Counters: characteristics, dead time and counting statistics 7. Scintillation detector-energy calibration, resolution and determination of gamma ray energy 8. Quinck's tube method to find susceptibility of a material 9. Nuclear Magnetic Resonance 10. Zeeman Effect 11. To study Lattice Dynamics	100
2	**(i) Electronics** 1. PCM/delta modulation and demodulation 2. Fiber optic communication 3. Modulation/Demodulation 4. 4-bit ripple counter **(ii) Thin Film and Nano-Material** 1. Data Analysis of XRD, SEM and TEM 2. Chemical Deposition (for CNT growth) 3. ZnO wire by thermal oxidation 4. Band gap estimation by Tauc-plot method 5. Thin film deposition technique 6. DTA/TGA analysis **(iii) Numerical Techniques** 1. Solution of Linear algebraic equation: Gauss Jordan elimination, Singular Value Decomposition, Sparse linear system. 2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function. 3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness.	80

	4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data. 5. Eigen systems: Solving eigenvalues and finding eigenfunctions of Schrodinger equation for analytically unsolvable potentials using variational principle.	

TEXT BOOKS
1. Albert Malvino, Digital Principles and Applications, McGraw Hill, New York, 4th Edition, 1986. 2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003. 3.W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007. 4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, and Complexity, Oxford University Press, 2nd Edition, 2007. 5. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1st Edition, 2017.

DSE Courses

(for Semester VII to IX)

Statistical Mechanics-II

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject: Statistical Mechanics-II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
VII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 701 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Graduation Level Quantum Mechanics and Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is developed for understanding of thermodynamics and statistical mechanics, which have broad and rich applicability in quantum mechanics, condensed matter physics, classical mechanics and electrodynamics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the fundamentals of thermodynamics and statistical mechanics
● To make familiar with various thermodynamical and statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.
● To able the students for solve the problems related to thermodynamics and statistical physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Explain the various thermodynamical quantities and Maxwell’s relations
● Apply the thermodynamics in ideal gas, magnetic and dielectric materials
● Describe various statistical approaches which describe systems of particles
● Evaluate the formulae of random walk and diffusion equation</td></tr>
</table>

	● Compare microstates, macrostates, and statistical ensembles ● Understand the theories and mathematical approaches of statistical ensembles, equipartition theorem and Maxwell-Boltzmann statistics ● Illustrate the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics ● Calculate the problems related to Bosons and Fermions	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Review of Thermodynamics:** Extensive and intensive variables, laws of thermodynamics, Entropy for Different Systems, Gibbs Paradox, Boltzmann Relation for Entropy, Legendre Transformations and Thermodynamic Potentials, Chemical Potential, Free Energy and Its Connection with Thermodynamic Quantities, Maxwell Relations, Applications of Thermodynamics to (a) Ideal Gas, (b) Magnetic Material, and (c) Dielectric Material.	15
2	**Statistical Methods and Description of Systems of Particles:** Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem, Random Walk and Brownian Motion, Diffusion Equation, Phase Space, Liouville's Theorem, Phase Equilibrium, Microstates and Macrostates, Statistical Ensembles, Irreversibility and the Attainment of Equilibrium	15
3	**Classical Statistical Mechanics:** Micro-Canonical Ensemble, Canonical Ensemble: Derivation of Partition Function and Thermodynamic Quantities; Mean Values and Fluctuations, Grand Canonical Ensemble: Gibbs Factor; Gibbs Distribution; Derivation of Partition Function and Thermodynamic Quantities; Fluctuations in the Number of Particles, Applications of Canonical and Grand Canonical Ensembles, Equipartition Theorem and It's Applications, Maxwell-Boltzmann Statistics.	15
4	**Quantum Statistical Mechanics:** Bosons: Occupation Number; Bose-Einstein Statistics; Debye Theory of Specific	15

	Heat; Grand partition function For Ideal Bose Gas; Black-Body Radiation; Bose-Einstein Condensation, Fermions: Occupation Number; Fermi-Dirac Statistics; Ideal Fermi gas, Pauli Paramagnetism, First and Second Order Phase Transitions, Ising Model, Phase Equilibria: Equilibrium Conditions; Simple Phase Diagrams; Clausius-Clapeyron Equation.	

TEXT BOOKS

1. F. Reif, Fundamental of Statistical and Thermal Physics, McGraw-Hill, USA, 1965.
2. L. D. Landau and E. M. Lifshitz, Statistical Physics, UK, 3rd Edition, 1980.
3. D. V. Schroeder, An Introduction to Thermal Physics, Addison Wesley Longman, UK, 2000.
4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford University Press, UK, 2006.
5. M. Kardar, Statistical Physics of Particles, Cambridge University Press, UK, 2007.
6. H. Gould and J. Tobochnik, Statistical and Thermal Physics: With Computer Applications, Princeton University Press, USA, 2010.
7. K. Huang, Statistical Mechanics, Wiley, India, 2nd Edition, 2011.
8. R. K. Pathria and P. D. Beale, Statistical Mechanics, Academic Press, USA, 2011.

Introduction to Hydrogen Energy Systems

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:

Introduction to Hydrogen Energy Systems</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VII</td><td>Contact hours per week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 702 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks):
100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">To introduce the concept of energy generation from Hydrogen as future fuel. To enlighten the knowledge of production, storage and transportation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">This course aim is to give insight of hydrogen production, storage and their application, as a future source of energy.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues.
There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. By observing energy efficient measures there is tremendous scope of saving energy in industry, built environment, transport etc.
To teach fundamentals of hydrogen energy as energy systems, production processes, separation and utilization that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.
This course has objectives to elaborate PG students regarding current trends in hydrogen energy architecture and following key concepts such as hydrogen storage and hydrogen sensing.
To Provide adequate inputs on a variety of issues relating to safety guidelines, codes and standards in hydrogen energy systems.</td></tr>
<tr><td></td><td colspan="7">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
</table>

1.	**Hydrogen Energy Pathways-** Properties of hydrogen, Global and Indian hydrogen energy scenario, need for hydrogen, current uses, environmentally sustainable hydrogen, hydrogen as part of Climate Neutral Strategy. Hydrogen for mobility applications & vehicles, Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications.	15
2.	**Hydrogen Production**-Production of hydrogen from hydrocarbons-oxidative and nonoxidative processes, coal. Hydrogen production using nuclear energy and renewables- wind, biomass, solar. **Hydrogen separation and purification**-Pressure swing adsorption, Solvent based absorption, membrane separation, cryogenic separation etc.	15
3.	**Hydrogen Storage -**Types of hydrogen storage (Gaseous, Liquid, Solid hosts), Gibbs Phase Rule, Pressure-Composition-Temperature plots; Van't Hoff plots for absorption desorption enthalpies, Gravimetric capacities, Hysteresis in cycling, Joule-Thomson Effect, Non-ideal treatment of hydrogen gas Kinetics: Hydrogen absorption/desorption phenomena (chemisorption, nucleation and growth and diffusion), Kinetic models, Kissinger analysis for activation energy estimation, Hydrogen adsorption isotherms-BET, design and applications of storage systems, materials for hydrogen storage, Hydrogen storage for automobiles.	15
4.	**Hydrogen sensing-**Traditional methods of hydrogen sensing using thermal conductivity measurements or Gas Chromatography, Mass Spectroscopy or laser gas analysis; Solid state sensors- their working principle and applications at industrial scale. **Hydrogen Safety-**Physiological, physical and chemical hazards, hydrogen properties associated with hazards, Hazard spotting, evaluation and safety guidelines, Hydrogen safety codes and standards. Hydrogen safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management.	15

REFERENCE BOOKS
1. F. Peter, Fuels and Fuel Technology, A.Wheatan & Co. Ltd., 1st edition, 1965. 2. JOM Bockris, Energy options: Real Economics and the Solar Hydrogen System, Halsted Press and London publisher, 1980. 3. S. Sarkar, Fuels and Combustion, Orient Longman, 2nd edition, 1990. 4. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006. 5. J. G. Speight, The chemisty & Technology of Petroleum, 4th edition, CRC Press, 2006. 6. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009. 7. J.G. Speight and B. Ozum, Petroleum Refining Process, CRC Press, 2009. 8. W. Lyons, Working Guide to Petroleum and Natural Gas Production Engineering, Elsevier Inc, 2009. 9. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons, 2010. 10. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013. 11. J. G. Speight, The Chemistry and Technology of Coal, CRC Press, 2013.

Astrophysics of Stars

Scheme Version: 2022-27	**Name of the subject: Astrophysics of Stars**	**L**	**T**	**P**	**C**	**Semester:** VII	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours:** 60
Subject Code: SBS PHY 03 703 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Introduction to Astronomy and Astrophysics**		

Course Description	Aim of the Course : Stars are the fundamental building blocks of the Universe. By injecting vast amounts of energy and momentum into their surround-ings, they act as drivers for the evolution of their host galaxies..
Course Objectives	Aim of this course is to understand in detail what goes on deep inside an object that, to us, is a mere pinprick of light in the sky.
Course Outcomes	On completion of the course, student would be able to ● Quantify the basic parameters of stars. ● Understand how radiation interacts with matter at the surfaces of stars ● Understand how to produce the spectra that we observe ● Know about the processes that determine the interior structure, composition and evolution of stars.

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Stellar Observations:** Introduction, Distance & magnitude, Blackbody radiation, Colors & line spectra, Binary systems: visual binaries, Eclipsing & spectroscopic binaries, The Hertzsprung-Russel diagram, Spectral classification	15
2	**Stellar Atmospheres:** Stellar atmospheres, Describing radiation, Radiation & matter , Radiative transfer, The Eddington approximation, The grey atmosphere, Realistic model atmospheres, Opacity sources, Spectral features, Profile shapes, Line strengths	15
3	**Stellar Interiors:** Mechanical structure, The virial theorem, Polytropes, Equation of state, Energy conservation; diffusive transport, Mass-luminosity relation; main sequences, Convective transport, Energy generation, Nuclear fusion networks, Fusion rates, Rotation, Stellar model building	15

4	**Stellar Evolution:** The main sequence, The Sun, Massive stars, Star formation, Pre-main-sequence evolution, Evolution off the main sequence, Helium burning & beyond, Stellar death, Stellar pulsation, White dwarfs, Neutron stars	15
Text Books		
1. "An Introduction to Modern Stellar Astrophysics", Bradley W Carroll and Dale A Ostlie (ISBN: 978-08053034830), Cambridge University Press (2017) 2. "Stellar Structure and Evolution", R. Kippenhahn & A. Weiger, (2012) Springer-Verlag Berlin Heidelberg 3. Structure and Evolution of the Stars, by M. Schwarzschild. (ISBN : 9780691652832), 2016, Princeton University Press 4. Stellar Atmospheres, by Ivan Hubeny , Springer Verlag 5. Radiative Processes in Astrophysics : G. Rybiki and A. Lightmann, 2004 WILEY‑VCH Verlag GmbH & Co.		

Digital Electronics and Microprocessor

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Digital Electronics and Microprocessor</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 801 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course covers the topics of Microprocessors, Assembly language, interfacing data converters and peripheral devices, and microcontrollers.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course on Semiconductor Devices is to introduce semiconductor physics, physical principle of devices and their basic applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
● To understand the basic properties of microprocessors and Assembly language.
● To understand basic properties of interfacing data converters and interfacing peripheral devices.
● To understand the working, design and applications of microcontrollers.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Microprocessor:** Buffer registers, Bus oraganised computers, SAP-I, Microprocessor (P) 8085 Architecture, memory interfacing, interfacing I/O devices. Assembly language programming : Instruction classification, addressing modes, timing diagram, Data transfer, Logic and Branch operations-Programming examples.	**15**

2	**Programming techniques** for 8085 microprocessor, Counters and timer delays, Stack and subroutines, Code conversion, BCD, Arithmetic and 16-bit Data operations, Interrupts of 8085, Vectored and nonvectored, maskable and nonmaskable interrupts. **Interfacing data converters** – A/D and D/A, Programmable interface devices – 8255A programmable interface, Interfacing keyboard/Display and Seven-segment display	**15**
3	**Interfacing Programmable Peripheral Devices** – interfacing keyboard and seven segment display, 8254 programmable interval timer, 8259A programmable interval timer, 8259 Programmable Interrupt Controller. Serial communications, Software controlled Asynchronous Serial I/O, Programmable communications interface 8251, RS232	**15**
4	**Microcontrollers** - Overview of the 8051 family, Architecture of 8051, Timers, Interrupts and serial communication in 8051, 8051 programming in C, 8051 timer programming in C, Serial port programming, Interrupts programming.	15

TEXT BOOKS

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085, (Prentice Hall) 2002.
2. Badri Ram, Advanced Microprocessors and Interfacing, (Tata McGraw Hill), 2001.
3. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware (Tata McGraw Hill) 2005.
4. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M. Mckinley (Pearson Education) 2009.
5. The 8051 Microcontroller – I. Scott Mackenzie, R. Chung Wei Phan (Dorling Kindersley (India)), 4th ed. 2007.
6. Microcontrollers - A.J. Ayala, (Penram International), 2nd ed. 1996.
7. Microcontrollers : Arch., Programming, Interfacing & System design, Rajkamal, (Dorling Kindersley (India)), 2009.
8. Microcontroller (Theory & Applications), Ajay V Deshmukh (Tata McGraw Hill) 2012.
9. Embedded System Design, Rajeshwar Singh (Dhanpat Rai), 2nd Ed. 2009.

Solar Energy and Physics of Photovoltaics

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:
Solar Energy and Physics of Photovoltaics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VIII</td><td>Contact hours per week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 802 DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of course: There is no prerequisite or corequisite for this course. But students are expected to know basic semiconductor physics.</td></tr>
<tr><td>Course Description</td><td colspan="7">The course is intended for students who have interest in alternate energy sources as a contributor to sustainability. It provides a comprehensive treatise on the science and technology of solar energy, its collection and the design principles that need to be understood for its effective use in a variety of installations and uses.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● The Course will be introducing the students to all the aspects of PV technology.
● To develop basic understanding related to fabrication and characterization of different types of solar cells.
● To know state of art in the field of solar cells materials and solar cells.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:
● The available solar energy and the current solar energy conversion and utilization processes, solar spectrum.
● The factors that influence the use of solar radiation as an energy source.
● The various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.
● How solar cells convert light into electricity, how solar cells are manufactured, how solar cells are evaluated.</td></tr>
</table>

	● What technologies are currently on the market, and how to evaluate the risk and potential of existing and emerging solar cell technologies. ● To examine the potential & drawbacks of currently manufactured technologies, as well as pre-commercial technologies. How to enhance solar cell performance and reduce cost, and the major hurdles-technological and economic, towards widespread adoption.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**Solar Radiation:** origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, sun tracking systems, photo thermal conversion, solar energy collectors, collector efficiency and its dependence on various parameters.	15
2.	**Solar energy:** storage of solar energy, solar pond, solar water heater, solar distillation, solar cooker, solar green houses, solar dryers, absorption air conditioning. solar fuels: electrolysis of water, photoelectrochemical splitting of water.	15
3.	**Fundamentals of solar cells:** Photovoltaic effect, semiconductor properties, energy levels, basic equations, p-n junction its characteristics, fabrication steps, thermal equilibrium condition, depletion capacitance, junction breakdown, heterojunction. Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells.	15
4.	**Device physics**: Solar cell device structures, construction, output power, efficiency, fill factor and optimization for maximum power, surface structures for maximum light absorption, current voltage characteristics in dark and light, operating temperature vs conversion efficiency, charge carrier generation, recombination and other losses. Cadmium telluride solar cells, copper indium gallium selenide solar cells, organic solar cells, perovskite solar cells, Advanced concepts in photovoltaic research.	15

REFERENCE BOOKS
1. S P Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 1996. 2. Solid State Electronic Devices, Ben. G. Streetman, S. K. Banerjee, PHI Leaning Pvt. Ltd, 2000. 3. D. Yogi Goswami, Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, Taylor and Francis, 2000. 4. Jasprit Singh, Semiconductor Devices, Basic Principles, Wiley, 2001 5. Stephen J.Fonash, Solar Cell Device Physics, 2nd edition, Academic Press, 2003. 6. H P Garg, J Prakash, Solar energy fundamentals and applications, Tata McGraw Hill publishing Co. Ltd, 2006.

General Theory of Relativity

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject: General Theory of Relativity</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 803
DS 4004</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Classical Electrodynamics, Mathematical Physics-I, II, III</td></tr>
<tr><td>Course Description</td><td colspan="7">This course on General Theory of Relativity covers topics of Special Theory of Relativity, General Theory of Relativity and its applications.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The objective of the course is to familiarize students with different aspects of theory of gravitation.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to
Understand the mathematical rigour that goes behind the theory of relativity and also be able to
Understand few applications of general theory of relativity.
Understand the Special theory of relativity
Understand the origin of gravitational waves</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Historical Background : Review of Newtonian Mechanics. Special theory of relativity. Prelude to General relativity, historical developments, 4-Vectors and 4-tensors, examples from physics</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Tensors in GTR: Principle of Equivalence, Equations of motion, Gravitational force, Tensor Analysis in Riemannian space, Effects of Gravitation, Riemann-Christoffel curvature tensor, Ricci Tensor, Curvature Scalar</td><td>15</td></tr>
</table>

3	**Applications of GTR:** Einstein Field Equations, Experimental tests of General Theory of Relativity, Scwartzchild Solution, Gravitational lensing	15
4	**Gravitational Radiation:** Gravitational waves: generation and detection, Energy, momentum and angular momentum in Gravitation	15
Text Books		
1. S. Weinberg, Cosmology, Oxford University, 1st Ed., 2008. 2. Ray D'Inverno, Introducing Einstein's General Relativity, Oxford University, 1st Ed., 1992. 3. M. Berry, Principle of Cosmology and Gravitation, Taylor & Francis; 1st Ed., 1989. 4. Tai L. Chow, Introduction to General theory of Relativity and Cosmology, Springer, 1st Ed., 2008. 5. P.A.M. Dirac, General theory of Relativity, Wiley-Blackwell, 1st Ed., 1975. 6. L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Publishere, Shroff, 2nd Ed., 2010		

Accelerator Physics

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject:
Accelerator Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 804 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Nuclear Physics, Electrodynamics, Quantum mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to expose the students to theoretical design and usage of various particle accelerators.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the beam optics.
● Get knowledge about different types of accelerators
● To understand the main features of superconducting cyclotron, linear accelerators and high energy accelerators.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
● Understand the beam optics & beam transport system.
● Learn about various theoretical techniques to accelerate particles and technical details of electrostatic accelerators.
● Get knowledge about latest accelerator technology based on Rf cavities.
● Learn about Synchrotron Radiations & production of radioactive ion beams.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Charged Particle Dynamics:** Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.	15
2	**Electrostatic and Heavy Ion Accelerators:** Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams.	15
3	**Radiofrequency Accelerators:** Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs, Superconducting Heavy Ion Linear Accelerators. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.	15
4	**Synchrotron Radiation Sources:** Electromagnetic radiation from relativistic electron beams, Electron synchrotron, Characteristics of synchrotron radiation. Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators.	15

TEXT BOOKS

1. M.S. Livingston and J.P. Blewel, Particle Accelerators, McGraw-Hill Book Press, 1962.
2. Ed. J. Cerny, Nuclear Spectroscopy and Reactions Part-A, Academic Press, 1974.
3. H.J. Wiedman, Particle Accelerator Physics, Vol I and II, Springer Verlag, 1998.
4. S. Y. Lee, Accelerator Physics, World Scientific, Singapore, 2004

Characterization Techniques for Materials

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject:
Characterization Techniques for Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester:
VIII</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 805 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration:
3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="8">This course covers the fundamental principles and practical applications of different classes of materials and characterization techniques. The course discusses characterization techniques used for chemical and structural analysis of materials, including metals, ceramics, polymers, composites, and semiconductors. The topics include important spectroscopic, microscopic and thermal methods for materials characterization.</td></tr>
<tr><td>Course Objective</td><td colspan="8">● To introduce the materials characterization techniques to the students
● Help the students to understand the instrumentation aspects
● To provide a detailed understanding of data interpretation
● To provide hands on experience of the characterization techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">On completion of the course, student would be able:
● To determine crystal structure of specimen and estimate its crystallite size and stress
● To choose an appropriate microscopy techniques to investigate microstructure of materials at high resolution
● To use appropriate spectroscopic technique to measure vibrational/electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
● To apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen.</td></tr>
</table>

<table>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**Structure analysis:** X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Phase identification, indexing and lattice parameter determination, Powder X-ray diffractometer. Applications of XRD in bulk and nano-materials.	15
2	**Microscopy techniques: I**ntroduction to Microscopes, Optical microscopy, Transmission Electron Microscopy (TEM); Basic Electron scattering, Concepts of resolution, TEM instruments, Various imaging modes, Analysis of micrographs, Electron Energy Loss Spectroscopy, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (AFM and STM)	15
3	**Spectrophotometric analysis of materials:** UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron Spectroscopy (XPS).	15
4	**Thermal analysis techniques:** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA) **Electrical characterization techniques:** Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance	15

TEXT BOOKS

1. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, 1986.
2. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth Heinemann, 1993.
3. Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, 2000.
4. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, 2001.
5. B. Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-Destructive Testing, 2nd ed., Narosa Publishing House, 2002.
6. D. A. Skoog, F.J. Holler, S. R. Crouch, Instrumental Analysis, Cengage Learning, 2007.
7. Li Lin, Ashok Kumar, Materials Characterization Techniques Sam Zhang; CRC Press, 2008.
8. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
9. J. C. Vickerman, I. Gilmore, Surface Analysis: The Principal Techniques, 2 nd ed., John Wiley & Sons, Inc.2009.

Cosmology

<table>
<tr><td rowspan="2">Scheme Version:

2022-27</td><td rowspan="2">Name of the subject: Cosmology</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 901 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Introduction to Astronomy and Astrophysics</td></tr>
<tr><td>Course Description</td><td colspan="7">Cosmology is a branch of astronomy that involves the origin and evolution of the universe, from the Big Bang to today and on into the future.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The aim of this course is to introduce the model of the universe on large scales</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to
Understand the concepts of STR and GTR
Apply the concepts of GTR to cosmology
Understand the model of expanding universe
Explain the model of early universe and its thermal history.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Principles of Relativity: Overview of Special Relativity - spacetime interval and Lorentz metric- four vectors - Introduction to general relativity (GR) - equivalence principle - notions of curvature</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Gravitation as a manifestation of the curvature of spacetime: Gravitational redshift and clock corrections - orbits in strong gravity, light bending and gravitational lensing - concept of horizon and ergosphere, hydrostatic equilibrium in GR - gravitational radiation.</td><td>15</td></tr>
<tr><td>3</td><td colspan="6">Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder –Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble’s law - Robertson-</td><td>15</td></tr>
</table>

	Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman-Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes.	
4	**Physical Cosmology and Early Universe:** Thermal History of the Universe - distribution functions in the early Universe – relativistic and nonrelativistic limits - Decoupling of neutrinos and the relic neutrino background - Nucleosynthesis - Decoupling of matter and radiation – Cosmic microwave background radiation (CMB)- Anisotropies in CMB - Inflation – Origin and growth of Density Perturbations - Formation of galaxies and large scale structures - Accelerating universe and type-Ia supernovae - The Intergalactic medium and reionization.	15

Text Books
1. Cosmological Physics, Cambridge University Press, J . A. Peacock 2. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010 3. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan,Cambridge University Press, 2002 (for lectures on Cosmology) 4. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994 (For more material on General Relativity). 5. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology). 6. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity). 7. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995 (for material on Cosmology and Structure formation).

Plasma Physics

Scheme Version: 2022-27	**Name of the subject:** Plasma Physics	**L**	**T**	**P**	**C**	**Semester:** IX	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours:** 60
Subject Code: SBS PHY 03 902 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Quantum Mechanics		

Course Description	Students will be exposed to theory related to motion of charge particle in an inhomogeneous field, production of plasma and usage of plasma.
Course Objectives	• To make students familiar with fourth state of matter • To aware students about plasma creation in laboratory • To make students familiar with production of energy in fusion reactor
Course Outcomes	After completion of this course, the students will have understanding of • what are theoretical method to study the charge particle motion • Idea behind the magnetic confinement • how to generate plasma in the laboratory • how plasma production is helpful to make fusion reactors

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction**: Plasma state, plasma parameters, applications of plasmas.	15

	Single particle orbit theory: Drift of charge particle under different combinations of electric and magnetic field, crossed electric and magnetic fields, homogenous electric and magnetic fields, spatially and time varying electric and magnetic fields,	
2	**The Boltzmann Equation:** Simplified magneto-hydrodynamic equations - Electron plasma oscillations Debye shielding phenomenon and criteria for plasma, motion of charged particles in electromagnetic field, Electric field drift, parallel acceleration, curvature drift, adiabatic invariants; fundamental equations of magneto-hydrodynamics(MHD), magnetic confinement.	15
3	**Production of Plasma in laboratory:** Physics of glow discharge, electron emission, ionization breakdown of gasses, Paschen's law and different regimes of E/ρ in a discharge. **Plasma diagnostic:** Probes, energy analysers, magnetic probes and optical diagnostics, preliminary concepts.	15
4	**Fusion Reactor**: Potential of fusion energy, controlled thermonuclear reactions, fusion reactions, fusion cross-sections, fusion power generation, energy balance for fusion systems, ignition criterion, gain factor, plasma heating, ohmic heating, neutral beam injection, radio frequency heating, inertial confinement fusion, tokamaks, stability, operating limits and transport.	15

TEXT BOOKS

1. Nicholson, D. R., Introduction to Plasma theory, Wiley, 1983
2. Chen, F.F., Introduction to Plasma Physics, Springer, 1984
3. Sturrock, P.A., Plasma Astrophysics, Cambridge University Press, 1994
4. Choudhuri, A.R., The Physics of Fluids and Plasmas, Cambridge University Press, 1998

Experimental Techniques in Nuclear and Particle Physics

Scheme Version: 2022-27	**Name of the subject:** Experimental Techniques in Nuclear and Particle Physics	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
		4	0	0	4	IX	**Total Hours:** 60
Subject Code: SBS PHY 03 903 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Basics of Nuclear Physics and Particle Physics		
Course Description	This course is intended to familiarize the M.Sc. students to the experimental techniques used in the fields of nuclear physics and particle physics. Various detection techniques will be introduced followed by a description of on-detector and off-detector electronics.						
Course Objectives	● Get knowledge about various experimental techniques used in the fields of nuclear physics and particle physics. ● To get familiar with various detector systems and related electronics.						
Course Outcomes	After completion of this course, students would be able to: ● Get knowledge about different types of radiations & their interaction with matter. ● Understand the radiation exposure and its effects on the biological system. ● Learn about how to detect radiations. ● Get knowledge about the various electronic components of radiation detectors and pulse signal processing. ● Understand Learn about different existing detector facilities all around the world.						
COURSE SYLLABUS							
Unit No.	**Content of Each Unit**						**Hours of Each Unit**

1	**Radiation interactions:** Nuclear processes in radioactive sources: types of radiations & radiation sources; Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. Radiation protection, Biological effects of radiation, radiation monitoring.	15
2	**Detection of radiations:** General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Gas-filled detectors: Ionization chamber, Proportional counters, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Scintillation detector, Phoswich detectors, Cherenkov detector. Semiconductor detectors. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding.	15
3	**Detector electronics:** Electronics for pulse signal processing, CR-$(RC)^n$ and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers, overload recovery and pileup, Linear amplifiers, single-channel analyser, analog-to-digital converters, multichannel analyzer. Basic considerations in time measurements; Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.	15
4	**Experimental Facilities:** Detector systems for heavy-ion reactions: Large neutron detector array, gamma and charge particle detector arrays, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments**:** basics of Collider physics, Modern Hybrid experiments- CMS and ALICE.	15

TEXT BOOKS

1. W.R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer, Berlin Heidelberg, 2nd Edition, 1994.
2. Konrad Kleinknecht, Detectors for particle radiation, Cambridge University Press, 1999.
3. Richard Fernow, Introduction to Experimental Particle Physics, Cambridge University Press, 2001.
4. Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 4th Edition, 2010.

Reactor Physics

Scheme Version: 2022-27	**Name of the subject:** Reactor Physics	**L**	**T**	**P**	**C**	**Semester:** IX	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours:** 60
Subject Code: SBS PHY 03 904 DS 4004	**Applicable to Programs:** Integrated B.Sc. M.Sc. (Physics)	**Evaluation (Total Marks :100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Description	This course is intended to impart primary but wide theoretical knowledge about nuclear reactors and related topics.						
Course Objectives	● To understand the theoretical and experimental knowledge about nuclear reactors. ● To know about the basic designs of nuclear reactors. ● To understand the need of nuclear fuel and waste management.						
Course Outcomes	After completion of this course, students would be able to: ● Understand the nuclear fission reactions. ● Learn about neutron sources and moderators. ● Get knowledge about working of nuclear reactors. ● Get knowledge about different types of power reactors ● Learn how to manage the nuclear fuel and waste.						

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Nuclear Reactions:** Characteristics of atomic nucleus, Binding energy, Nuclear fission, Cross section, Interaction of neutrons with nuclei.	15

2	**Neutron moderation**: Inelastic scattering, Elastic collisions, Moderating ratio, Slowing down Density, Resonance escape, Moderators, Neutron sources, Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.	15
3	**Nuclear Reactors:** Fuel materials, Moderator materials, Cladding materials, Coolant materials and control materials, Control requirement calculations, Means of control, Reactor kinematics: Neutron lifetime, Generation time, Point kinetic equation and solution of the equations for step input reactivity.	15
4	**Types of Power reactors & Fuel and waste management:** Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.	15

Laboratory Assignments:

Visits to fission reactor sites and related case studies for generation of nuclear energy.

TEXT BOOKS

1. Lamarshs, J.R., Introduction to Nuclear Reactor Theory, Addison-Wesley Publishing Co., 1966.
2. Glasstons, S. and Sesonske, A., Nuclear reactor Engineer, CBS Publishers & Distributors, 1986.

Advanced Carbon Materials

<table>
<tr><td rowspan="2">Scheme Version:
2022-27</td><td rowspan="2">Name of the subject: Advanced Carbon Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IX</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 905 DS 4004</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce students to the advanced carbon material that includes graphene, fullerenes, hierarchical carbon, and CNTs are referred to as the strength of revolution and advancement in the era of material science and technology. In general, the 20th century corresponds to plastic, while the 21st century will be named as “Century of Graphene” owing to its exceptional physical properties.</td></tr>
<tr><td>Course Objective</td><td colspan="7">On completion of the course, student would be able:
● To understand various properties of Graphene, CNTs and Fullerenes</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
● To understand the basic properties of carbon
● To understand the various properties and applications of graphene
● To understand the various properties and applications of CNT
● To understand the various properties and applications of fullerenes</td></tr>
</table>

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Introduction:** Carbon atomic structure and hybridization, carbon on the Earth and in outer space, carbon in technology and economy, carbon isotopes: classification of carbon allotropes, conversion of	**15**

	one allotropic form into another, phase diagram of carbon, new carbon structures: discovery of C_{60}, Graphene and Nanotubes	
2	**Graphene:** Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties – Band Structure of Graphene - Mobility and Density of Carriers - Quantum Hall Effect – Characterization of graphene: Raman Spectroscopy, Infrared Spectroscopy, Absorption and Photoluminescence Spectroscopy, Atomic Force Microscopy, Application of graphene	**15**
3	**Carbon Nanotubes:** The Structure of Carbon Nanotubes- Nomenclature, Structure of Single-Walled Carbon Nanotubes and Structure of Multiwalled Carbon Nanotubes; Synthesis of CNT by various physical and chemical methods and Purification, Characterization of Carbon Nanotubes: Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes. Application of CNTs	**15**
4	**Fullerenes**: Structure and Bonding- Nomenclature, The Structure of C60, Structure of Higher Fullerenes - Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties-, Spectroscopic Properties, Thermodynamic Properties; Chemical Properties- Hydrogenation and Halogenation, Nucleophilic Addition to Fullerenes. Application of Fullerenes	**15**

TEXT BOOKS

1. M.S. Dresselhaus, G. Dresselhaus and P.C. Eklund, Science of Fullerenes and Carbon Nanotubes, Elsevier, 1996.
2. Yury Gogotsi, Carbon Nanomaterials, Taylor and Francis, 2006.
3. Francois Leonard, The Physics of Carbon Nanotube Devices, Elsevier, 2008.
4. Anke Krueger, Carbon Materials and Nanotechnology, Wiley-VCH, 2010.
5. D.R. Askeland, P.P. Phule, W.J. Wright, The Science and Engineering of Materials, 6th ed., Cengage Learning, 2010.
6. Jamie H. Warner, Franziska Schäffel, Mark H. Rümmeli, Graphene: Fundamentals and emergent applications, Elsevier, 2013.
7. T. Pradeep, NANO: The Essentials- Understanding Nanoscience and Nanotechnology, McGraw Hill Education, 2017.
8. Deborah D L Chung, Carbon Materials: Science and Applications, World Sci., 2019.

8. Teaching-Learning Process

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

9. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasises student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimises and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, be adopted.

Note: MOOC courses (SWAYAM) having similarity more than 75% with the core courses may be offered to the students. For SEC/GEC/AECC/DSEC courses, the students may opt from the MOOC courses provided these courses are not in the list of core courses and students have not studied similar courses earlier. Since, the list of MOOC courses keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

10. Assessment and Evaluation

- The question paper for End Semester examination may contain up to 40% of numericals.
- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

11. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Graduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

12. References

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf
- Learning Outcomes based Curriculum Framework (LOCF) for Undergraduate Programme B.Sc. (Physics) 2019 https://www.ugc.ac.in/pdfnews/1884134_LOCF-Final_Physics-report.pdf

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

Based upon CBCS, LOCF and NEP-2020

Curriculum and Syllabi
of
M.Sc. Physics

(w.e.f. October 2021)
Revised

DEPARTMENT OF PHYSICS & ASTROPHYSICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	Approved	Approved	
Approval Date :	08-08-2022	12-08-2022	

Table of Contents

VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a platform for the dissemination and creation of knowledge through teaching and research in Physics and Astrophysics at various levels. To help create a scientific society which encourages logical thinking.

Mission

- To offer a state of art Academic Programs in Physics and interdisciplinary areas.
- To create intellectual property through innovations, quality research publications and patents
- To create state of art research laboratories which will facilitate the research of Central University of Haryana as well as other academic institutions.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of “Comprehensive Roadmap for Implementation of NEP-2020” in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on ‘creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills’ for the ‘development of an enlightened, socially conscious, knowledgeable, and skilled nation’.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering ‘Knowledge of India’; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About the Subject

Physics is the natural science that studies the matter, its motion and behavior through space and time, and the related entities of energy and force. Physics is one of the most fundamental scientific disciplines and its main goal is to understand the behavior of universe and its characteristics.

Physics uses the scientific method to help uncover the basic principles governing light and matter, and to discover the implications of those laws. It assumes that there are rules by which the universe functions, and that those laws can be at least partially understood by humans. It is also commonly believed that those laws could be used to predict everything about the universe's future if complete information was available about the present state of all light and matter.

On inclusion of Astronomy, the Physics became one of the oldest academic disciplines. Physics intersects with many interdisciplinary areas of research. New ideas in Physics often explain the fundamental mechanisms studied by other branches of science and suggest new avenues of research in academic disciplines such mathematics etc. Advancement in Physics often leads to new technologies.

iii)About the Programme (Nature, extent and aims)

M.Sc. Physics is a two year regular programme. There four semesters in this programme. Each semester is of sixteen weeks duration. Teaching and learning process of M.Sc. Physics involves theory and practical classes along with seminar presentation and research project work.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools and other teaching aids can be used as and when required. Emphasis will be given to laboratory work and visit to National laboratories to give hands on experience to students. Students will be encourage to do semester long project in their own institutes as well as in reputed institutes of National level. Aims of the Programme are as follows

- Understand the underlying Physics in respective specializations, and, be able to teach and guide successfully
- Introduce advanced ideas and techniques that are applicable in respective fields.
- Provide the students with a broad spectrum of Physics Courses
- Emphasize the role of Physics in other disciplines such as (Chemical Sciences, Mathematical Sciences, Life Sciences and their applied areas)
- Develop the ability of the students to observe, perform, analyse and report an experiment

- Develop the ability of the students to deal with physical models and formulas mathematically
- Equip the students with different practical, intellectual and transferable skills.
- Strengthen the student knowledge of Physics and its applications in real world.
- Provide the student with mathematical and computational tools and models to be used in solving professional problems
- Improve the student's inter disciplinary skills.
- To develop human resources with a solid foundation in theoretical and experimental aspects of respective specializations as a preparation for career in academia and industry.

iv) Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive M.Sc. Degree in the Physics. The postgraduate of Department of Physics and Astrophysics are expected to opt different paths seeking sphere of knowledge and domain of professional work that can fulfill their dreams. Students will be able to demonstrate their knowledge in advance branches of Physics. This will establish a platform over which students can pursue higher studies. The possible career paths for postgraduate in M.Sc. Physics are

1. Teaching Assignments
2. Scientific Assignments
3. Instruments development
4. Research and Development in Industries
5. Simulation Techniques Development in Science
6. Role in Renewable Energy Resources
7. University/Institute Administrative Assignments
8. Technician in Lasers, Accelerators, Detectors and Electronics
9. Astronomer
10. Medical Device Designer
11. Radiologist

2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following specific outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	Identify, formulate, and solve Physics problems
PSO-2	Design and conduct experiments, as well as to analyse and interpret data
PSO-3	Apply knowledge of Physics in a different stream of science and to communicate effectively.
PSO-4	Ability to use the techniques, skills, and modern physical tools in real world application.
PSO-5	Engage in life-long learning and will have recognition.

4. Postgraduate Attributes

No.	P.G. Attributes
PGA-1	have the ability to demonstrate advanced independent critical enquiry, analysis and reflection
PGA-2	In-depth knowledge of their specialist discipline(s)
PGA-3	be critical and creative thinkers, with an aptitude for continued self-directed learning
PGA-4	be able to examine critically, synthesize and evaluate knowledge across a broad range of disciplines.
PGA-5	Reach a high level of achievement in writing, research or project activities, problem solving and communication.
PGA-6	have a set of flexible and transferable skills for different types of employment
PGA-7	have a strong sense of intellectual integrity and ethics of scholarship.
PGA-8	be able to initiate and implement constructive change in their communities, including professions and workplaces.

5. STRUCTURE OF MASTER'S COURSE

Total Credits of M.Sc. Physics : 96

Types of Courses	**Nature**	**Total Credits**	**%**
Core Courses(CC)	Compulsory	60	**62.5**
Elective Courses (EC)	Discipline Centric Elective Courses	0	**0**
	Discipline Specialized Elective Courses	16	**16.6**
	Generic Elective Courses	8	**8.3**
Skilled-based courses/ Self-study based courses	Skill Enhancement Courses	12	**12.5**

List of Courses (*, **, *, ****)**

6. LEARNING OUTCOME INDEX

6.1A Mapping of Core Courses with PSOs

POs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5
Course No. ⇩					
1	√		√		√
2	√		√		√
3	√		√		√
4	√	√		√	
5	√	√			√
6	√		√		√
7	√		√		√
8	√		√		√
9	√	√	√		
10	√	√		√	
11	√		√	√	
12	√		√	√	
13	√	√			√

14	√		√	√	

6.1B Mapping of Discipline Centric Courses with PSOs

POs ⇨	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
Course No. ⇩					
1	√				√
2	√	√		√	√
3		√		√	√
4		√		√	√
5	√		√		√
6		√	√	√	
7	√	√			√
8		√	√	√	
9	√	√	√		
10	√		√		√
11	√		√		
12	√		√		√
13		√	√	√	
14		√	√	√	
15	√		√		
16	√		√		√
17	√		√		√
18	√		√		√
19	√		√		√
20	√	√			
21	√	√		√	
22	√		√	√	
23	√			√	√
24		√		√	

25		√		√	
26	√			√	√
27	√	√			

7. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

Note: This scheme supersedes the earlier available schemes before this date.

SEMESTER-I (26-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Core Courses								
1	1	SBS PHY 01 101 CC 3104	Mathematical Methods in Physics – I	3	1	0	4	4
2	2	SBS PHY 01 102 CC 3104	Classical Mechanics	3	1	0	4	4
3	3	SBS PHY 01 103 CC 3104	Quantum Mechanics – I	3	1	0	4	4
4	4	SBS PHY 01 104 CC 3104	Semiconductor Devices	3	1	0	4	4
5	5	SBS PHY 01 105 CC 00126	Laboratory-I	0	0	12	12	6
Generic Elective Courses (for students of other Departments)								
6	1	SBS PHY 01 101 GEC 2124	Numerical Methods and Programming	2	1	2	7	4
7	2	SBS PHY 01 102 GEC 3104	Modern Optics	3	1	0	4	4
8	3	SBS PHY 01 103 GEC 3104	Physics of Digital Photography	3	1	0	4	4
9	4	SBS PHY 01 104 GEC 2002	Renewable Energy Resources	4	0	0	4	4

SEMESTER-II (26-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Core Courses								
1	6	SBS PHY 01 201 CC 3104	Statistical Mechanics	3	1	0	4	4
2	7	SBS PHY 01 202 CC 3104	Classical Electrodynamics	3	1	0	4	4
3	8	SBS PHY 01 203 CC 3104	Mathematical Methods in Physics- II	3	1	0	4	4
4	9	SBS PHY 01 204 CC 00126	Laboratory II	0	0	12	12	6
Discipline Centric Elective Courses								
5	1	SBS PHY 01 201 DCEC 3104	Quantum Mechanics – II	3	1	0	4	4
6	2	SBS PHY 01 202 DCEC 3104	Introduction to Astronomy and Astrophysics	3	1	0	4	4
7	3	SBS PHY 01 203 DCEC 3104	Fundamentals of Solar Energy	3	1	0	4	4
8	4	SBS PHY 01 204 DCEC 3104	Accelerator Physics	3	1	0	4	4
9	5	SBS PHY 01 205 DCEC 3104	Radiation Physics	3	1	0	4	4
Discipline Centric Skill based courses								
10	6	SBS PHY 01 206 DCEC 3024	Computational Physics	3	0	2	5	4
11	7	SBS PHY 01 207 DCEC 3104	Analog Electronics	3	1	0	4	4
Generic Elective Courses (for students of other Departments)								
12	5	SBS PHY 01 201 GEC 3104	Environmental Physics	3	1	0	4	4
13	6	SBS PHY 01 202 GEC 2002	Latex for Humans	1	0	2	3	2

SEMESTER-III (28-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs / Week	Total Credits
Core Courses								
1	10	SBS PHY 01 301 CC 3104	Atomic, Molecular Physics and Lasers	3	1	0	4	4
2	11	SBS PHY 01 302 CC 3104	Nuclear Physics	3	1	0	4	4
3	12	SBS PHY 01 303 CC 3104	Solid State Physics	3	1	0	4	4
4	13	SBS PHY 01 304 CC 00126	Laboratory-III	0	0	8	8	4
5	14	SBS PHY 01 305 CC 0202	Seminar Presentation	0	2	0	2	2
6	15	SBS PHY 01 306 CC 2002	Research and Publication Ethics	2	0	0	2	2
Discipline Centric Elective Courses								
5	6	SBS PHY 01 301 DCEC 3104	Physics of Electronic Materials and Devices	3	1	0	4	4
6	7	SBS PHY 01 302 DCEC 3104	Nuclear Reactor Physics	3	1	0	4	4
7	8	SBS PHY 01 303 DCEC 3104	Plasma Physics and Fusion Reactor	3	1	0	4	4
8	9	SBS PHY 01 304 DCEC 3104	Physics of Nanomaterials	3	1	0	4	4
9	10	SBS PHY 01 305 DCEC 3104	General Theory of Relativity	3	1	0	4	4
10	11	SBS PHY 01 306 DCEC 3104	Astrophysics of Stars	3	1	0	4	4
Discipline Centric Skill based courses								
11	12	SBS PHY 01 307 DCEC 3024	Characterization Techniques for Materials	3	0	2	5	4
12	13	SBS PHY 01 308 DCEC 3104	Digital Electronics and Microprocessor	3	1	0	4	4
13	14	SBS PHY 01 309 DCEC 3104	Programming with Python	3	1	0	4	4

SEMESTER-IV (16-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Major Research Project								
1	1	SBS PHY 01 401 PROJ 000	Dissertation	0	0	0	16	16
Discipline Centric Elective Courses								
2	15	SBS PHY 01 401 DCEC 3104	Advanced Nuclear Physics	3	1	0	4	4
3	16	SBS PHY 01 402 DCEC 3104	Particle Physics	3	1	0	4	4
4	17	SBS PHY 01 403 DCEC 3104	Cosmology	3	1	0	4	4
5	28	SBS PHY 01 404 DCEC 3104	Ferroelectricity and Magnetism	3	1	0	4	4
6	19	SBS PHY 01 405 DCEC 3104	Advanced Carbon Materials	3	1	0	4	4
Discipline Centric Skill based courses								
7	20	SBS PHY 01 406 DCEC 3104	Experimental Techniques in Nuclear and Particle Physics	3	1	0	4	4
8	21	SBS PHY 01 407 DCEC 3104	Astronomy Laboratory	3	1	0	4	4
9	22	SBS PHY 01 408 DCEC 3104	Vacuum Science and Thin Film Technology	3	1	0	4	4
10	23	SBS PHY 01 409 DCEC 3104	Minor Project	3	1	0	4	4
11	24	SBS PHY 01 410 DCEC 3104	Introduction to Hydrogen Energy Systems	3	1	0	4	4

Note:

- This GEC* courses offered by the Department can only be taken by the students of other Departments. The students of the Physics Department will take GEC from other Departments.
- The Department may offer more than one discipline centric elective courses (DCECs) depending on specialization and strength of faculty members, and the number of students have to opt one of them for semester II. If class strength is less than 10, then that particular subject will not be offered.
- In semester III, students are required to opt DCEC (courses) out of more than two courses offered by the Department, depending on the specialization and strength of the faculty.
- In semester IV, the students have to opt four DCEC (courses) out of options offered by the Department or Students may opt for full semester major research project.

8. COURSE-LEVEL LEARNING OUTCOMES

Course Structure

Mathematical Methods in Physics I

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Mathematical Methods in Physics-I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester:

I
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 101 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course: B.Sc.</td></tr>
<tr><td>Course Description</td><td colspan="8">This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different papers of Physics course. It includes elements of matrices and group theory, introduction to tensor algebra, function of a complex variable and calculus along with an introduction to computational techniques and statistical measures used in physics Course.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">• Learning about matrices and groups
• Understanding basics of Tensors.
• Getting to know the significance of Complex algebra
• Understanding Numerical methods in Physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After successful completion of the course the student will be able to do the following :
CO101C.1 : To use matrices for solving linear algebraic equations and to use group theory for understanding of crystallography.
CO101C.2 : To use tensor transformation and related algebra in physics.
CO101C.3 : To solve real definite integrals in theoretical Physics.
CO101C.4 : To find roots of a given polynomial and understand the properties of a statistical distribution of point particles.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Matrices and Group Theory :
Linear vector spaces, matrix spaces, linear operators, eigenvectors and eigenvalues, matrix diagonalization, special</td><td colspan="2">15</td></tr>
</table>

	matrices. Symmetries and groups, multiplication table and representations, permutation group, translation and rotation groups, O(N) and U(N) groups.	
2	**Tensors Analysis :** Coordinate transformations, scalars, contravariant and covariant vectors, mixed and covariant tensor of second rank, addition, subtraction and contraction of tensors, quotient rule. Christoffel symbols, transformation of Christoffel symbols, Covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form.	15
3	**Complex Variables :** Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy-Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues–poles, essential singularities and branch points, residue theorem, Jordan's lemma, singularities on contours of integration, evaluation of definite integrals.	15
4	**Computational Techniques and Probability Theory:** Root of functions, interpolation, extrapolation, Integration by trapezoid and Simpson's rule, solution of first order differential equation : using Runge-Kutta method and Finite difference methods. , Preliminary Concepts : mean values, standard deviation, various moments; Random walk problem, Binomial distribution, Poisson distribution, Gaussian distributions, Lorentz distribution, Central Limit Theorem.	15

TEXT BOOKS

1. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications, Mineola, New York, Vol 1&2, 1970.
2. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, S.CHAND (Prentice Hall of India), New Delhi, 2^{nd} Edition, 1987.
3. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press. Cambridge, Massachusetts, 7^{th} Edition 2012
4. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc., Mineola, New York 3rd Edition 2014.
5. **E. Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons. Hoboken, New Jersey (United States), 10^{th} Edition, 2015.

6. **K. F. Riley, M.P. Hobson, and S. J. Bence,** Mathematical methods for Physicists and Engineers, S. CHAND (Cambridge University Press), New Delhi, 3rd edition, 2018.
7. **V. BALAKRISHNAN,** Mathematical Physics with Applications, Problems and Solutions, Ane Books, New Delhi, 1st Edition, 2018

Classical Mechanics

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Classical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 102 CC 3104</td><td rowspan="2">Applicable to Programs:M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Classical Mechanics to the students so that they are able to understand the Lagrangian & Hamiltonian mechanics of systems of particles interacting with various forces and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of classical mechanics
• To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
• To aware the students about applications of classical mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO102C.1. Understand the mechanics of system of particles, D'Alembert's principle, Lagrangian mechanics, & Euler's equation of motion.
CO102C.2. Learn about Hamiltonian formulation, Hamilton's Equations of Motion and Principle of least action.
CO102C.3. Learn Canonical Transformations & Hamilton-Jacobi theory.
CO102C.4. Learn about Rigid body dynamics including problems.
CO102C.5. Understand the two body central force problem and its related aspects.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Lagrangian Formulation and Central Force Problem:** mechanics of one and many particle systems, Virtual work, Constraints: holonomic and non-holonomic, D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton's Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem.	15
2	**Hamilton's Equations of Motion:** Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.	15
3	**Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variable: adiabatic invariance of action variable,the Kepler problem in action angle variables.	15
4	**Small Oscillations and Rigid Body Motion:** Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator. Orthogonal transformation, Eigenvalues of the inertia tensor, Euler equations, Eulerian angles, moment of Inertia. Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Coriolis force.	15

TEXT BOOKS
1. **A. Sommerfeld,** Mechanics, Academic Press, United States, 1st Edition, 1952. 2. **I. Percival and D. Richards**, Introduction to Dynamics, Cambridge University Press, 1st Edition1982. 3. **Ronald L. Greene,** Classical Mechanics with Maple, Springer, Germany, 2nd Edition, 2000. 4. **Herbert Goldstein, Charles Poole, John Safko,** Classical Mechanics, Pearson Education,UK, 3rd Edition, 2011. 5. **L.D. Landau and E.M. Lifshitz,** Mechanics, Butterworth-Heinemann, UK, 2nd Edition, 2012. 6. **N.C. Rana and P.S. Joag,** Classical Mechanics, Tata McGraw Hill, New Delhi, 1st Edition, 2015.

QUANTUM MECHANICS - I

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Quantum Mechanics – I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I

(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 103 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of quantum mechanics, which has comprehensive and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of quantum mechanics

• To make familiar with various quantum mechanical problems related to vector space, eigenvalue, Schrödinger equation, free particle, harmonic oscillator, potential barrier and well, angular momenta etc.

• To aware the students about applications of quantum mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After competition of this course, students will be able to

CO103C.1. explain the theories and phenomena of vector space, operators, Dirac’s notations, matrices, and commutators which are very helpful in solving the various quantum mechanics problems

CO103C.2. understand the uncertainty relation between two arbitrary operators

CO103C.3. distinguish the actual meaning of time independent and time dependent Schrodinger’s equations

CO103C.4. illustrate Ehrenfest theorem, Poisson Brackets, wave packets and wave</td></tr>
</table>

	functions position and momentum space **CO103C.5.** analyze the energy eigenvalues and wave functions of harmonic oscillator, infinite and finite square wells, free particle, and hydrogen atom **CO103C.6.** determine the transmission and reflection coefficients of potential barrier and potential step, and delta function well **CO103C.7.** recognize the importance of angular momentum and its applications in quantum mechanics **CO103C.8.** explain the physics behind the addition of angular momenta

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Mathematical Tools of Quantum Mechanics:** Vector Spaces, Linear Independence, Bases, Dimensionality, Linear Transformations, Similarity Transformations, Eigen Values and Eigen Vectors, Inner Product, Orthogonality and Completeness, Hilbert Space, Hermitian and Unitary Operators, Orthonormality, Completeness and Closure, Dirac's Bra and Ket Notation, Matrix Representation and Change of Basis, Operators and Observables, Commutation Relations, Uncertainty principle for two arbitrary Operators.	15
2	**Quantum Dynamics:** Time Evolution Operator, Stationary States, Schrodinger Equation, The Schrodinger versus the Heisenberg Picture, The Infinite Square Well and the Simple Harmonic Oscillator: Energy Eigenvalues and Energy Eigenstates, Connecting Quantum to Classical Mechanics: The Ehrenfest Theorem; Poisson Brackets and Commutators, Wave Packets, Wave Functions in Position and Momentum Space.	15
3	**Quantum Mechanics in One and Three Dimensions:** Properties of One Dimensional Motion: Bound States and Scattering States, The Free Particle, The Potential Step, The Potential Barrier and Well, The Finite Square Well, The Delta-Function Well, Three Dimension Problems: Hydrogen Atom.	15

4	**Angular Momenta and Approximate Analysis:** Orbital angular momentum, General Formalism of Angular Momentum, Eigenfunctions and Eigenvalues of Orbital Angular Momentum, Addition of Angular Momenta, Spin Angular Momentum: Stern-Gerlach Experiment; Pauli Matrices and Spinors, Clebsch-Gordan Coefficients.	15

TEXT BOOKS

1. **L. D. Landau and E.M. Lifshitz**, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3rd Edition, 1981.
2. **P. A. M. Dirac**, The Principles of Quantum Mechanics, Oxford University Press, UK, 4th Edition, 1988.
3. **R. Shankar**, Principles of Quantum Mechanics, Springer, Germany, 2nd Edition, 1994.
4. **N. Zettili**, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2nd Edition, 2009.
5. **J. J. Sakurai**, Modern Quantum Mechanics, Pearson, India, 2nd Edition, 2013.
6. **L. I. Schiff**, Quantum Mechanics, McGraw Hill Education, USA, 4th Edition, 2017.
7. **D. J. Griffiths**, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3rd Edition, 2018.
8. **C. Cohen-Tannoudji, B. Diu, and F. Laloe**, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2nd Edition, 2019.

Semiconductor Devices

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Semiconductor Devices</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 104 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the course on Semiconductor Devices is to introduce semiconductor physics, physical principle of devices and their basic applications.</td></tr>
<tr><td>Course Objective</td><td colspan="7">An understanding of basic semiconductor device physics
An understanding of the application of Field-Effect Transistors.
An understanding of the application of Bipolar Junction Transistors.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO104C.1. To understand the basic properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier injection/excitation.

CO104C.2. To understand how to find the Fermi energy level and carrier density in n-type and p-type semiconductors.

CO104C.3. To understand basic properties of PN junctions and Metal-Semiconductor junction.

CO104C.4. To understand the working, design and applications of various semiconducting devices like rectifiers, clippers, LED, Solar cells.

CO104C.5. To understand the working, design, and applications of BJTs and FETs.

CO104C.6. To understand the working, design and applications of Operational</td></tr>
</table>

	amplifier

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Semiconductors:** Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors: Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration in equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility: Effect of temperature, Doping and high electric field, Hall Effect.	**15**
2	**Junctions:** p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Diode Applications: Load-Line Analysis, Series Diode Configurations, Parallel and Series-Parallel Configurations (AND/OR Gates), Half-Wave Rectification, Full-Wave Rectification, Clippers, Clampers. Network with a DC and AC Source, LED, Solar cell and photodetectors, Metal-Semiconductor contact: Rectifying contact and Ohmic contact.	**15**
3	**Bipolar Junction Transistors (BJT):** Fundamentals of BJT, BJT Operation: Common-Base Configuration, Common-Emitter Configuration, Common-Collector Configuration, Limits of Operation, Minority carrier distribution, BJT DC Biasing: Operating Point, Fixed-Bias Configuration, Emitter-Bias Configuration, Voltage-Divider Bias Configuration, Collector Feedback Configuration, Emitter-Follower Configuration, **Field Effect Transistors:** JEFT: Construction and Characteristics of JFETS, Transfer Characteristics, MOSFET: Depletion-Type MOSFET, Enhancement-Type MOSFET, Transfer Characteristics.	**15**
4	**Operational Amplifiers:** Differential amplifier (DA)- Basic circuit of differential amplifier Operation of differential amplifier: Common-mode rejection ratio	

	(CMRR), DC analysis of differential, Applications of OP-amp: Inverting amplifier-Input and impedance of inverting amplifier, Noninverting amplifier-Voltage follower, Effect of negative feedback on OP-amp in feedback circuits, Summing amplifiers-Applications of summing amp, OP-amp as integrators and differentiators.	

TEXT BOOKS

1. **J.J. Cathey**, Schaum's Outline of Electronic Devices and Circuits, McGraw Hill, New York, 2nd Edition 2002.
2. **B. Streetman and S. Banerjee**, Solid State Electronics, Prentice Hall India, New Delhi, 6th Edition, 2006.
3. **Millman and Halkias**, Integrated Electronics, McGraw Hill, New York, 2nd Edition 2009.
4. **A.P. Malvino**, Electronic Principles, McGraw, New Delhi, New York 7th, Edition, 2009.
5. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Addison Wesley, United States, 4th Edition 2009.
6. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, New Delhi, 11th Edition, 2013.
7. **P. Horowitz and W. Hill**, The Art of Electronics, Cambridge University Press, 3rd Edition, 2015.

LABORATORY I

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Laboratory I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1^{st} Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 105 CC 00126</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the lab 1 is to train students to perform various experiments associated with Electronics, Quantum physics, Waves mechanics and Spectroscopy. Students assigned the general laboratory work will perform at least ten (10) experiments of the above mentioned list of Physics experiments and further 8 experiments from the C programming section.. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To give hands on experience to students for generating magnetic field and measurement of various parameters.
• To teach how temperature controlled oven works
• To take measurements of current and voltage using various equipment</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After competition of this course, the students will be able to
CO105C.1. learn various Physics aspects by performing the experiments related to electronic devices, atomic and molecular physics, light wave, sound waves etc.
CO105C.2. Learn Error analysis
CO105C.3. Use excel for plotting graphs</td></tr>
</table>

	CO105C.4. to do C programming

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	1. Hall Effect 2. Four Probe Method to find band gap of semiconductor 3. Electron Spin Resonance 4. Frank-Hertz experiment 5. PN Junction characteristics 6. Solar cell characteristics 7. Velocity of ultrasonic wave in liquids 8. Characteristics of MOSFET 9. Diode as voltage regulator 10. Ionization potential of mercury 11. Planck's constant using LED 12. Law of Malus 13. Zener diode characteristics	150
2	Introduction to C Programming: 1. Write a Program to calculate and display the volume of a CUBE having its height, width and depth. 2. Write a C program to perform addition, subtraction, division and multiplication of two numbers 3. Write a program to input two numbers and display the maximum number. 4. Write a program to find the largest and smallest among three entered numbers and also display whether the identified largest/smallest number is even or odd. 5. Write a program to find the roots of quadratic equation. 6. Write a program to check whether the entered year is leap year or not (a year is leap if it is divisible by 4 and divisible by 100 or 400.) 7. Write a program to find the factorial of a number. 8. Write a program to check number is Armstrong or not. 9. Write a program to find GCD (greatest common divisor or HCF) and LCM (least common multiple) of two numbers 10. Write a program to generate Fibonacci series.	30

TEXT BOOKS
1. **Worsnop and Flint,** Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951. 2. **A. C. Melissinos, J. Napolitano,** Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2^{nd} Edition, 2003. 3. Lab manuals, prepared by faculty of the Department of Physics, 2018.

Numerical Methods and Programming

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Numerical Methods and Programming</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>2</td><td>1</td><td>2</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 101 GEC 2124</td><td rowspan="2">Applicable to Programs: M.Sc.</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. With Mathematics.</td></tr>
<tr><td>Course Description</td><td colspan="7">This course teaches the students to solve basic problems of mathematics and sciences with the help of an approximation and a computer.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To make the student
• 1) Understand basics of a Programming Language
• 2) Aware of various Numerical methods.
• 3) Able to create hypothetical data sets for Physical Systems.
• 4) familiar with random sampling of large data sets.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Students will be able to learn :
CO101G.1 : to write a computer program in C.

CO101G.2 : the solutions of linear and non-linear equations along with solutions of simultaneous linear equations.

CO101G.3 : Numerical differentiation and integration.

CO101G.4 : Monte Carlo methods and its application to problems of physical world.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**C/C++:** Flow charts, Algorithms, Input and output statements, Control statements, Arrays, Repetitive and logical structures, Subroutines and functions.	15
2	Numerical Methods of Analysis: Roots of a function, Solution of simulteneous linear	35

	equation, Interpolation and curve fitting, Numerical differentiation and integration, Solution of ordinary differential equations	
3	Simulations I: Generation of random numbers, Statistical tests of randomness,, Monte-Carlo evaluation of integrals and Error Analysis.	35
4	Simulations II : Inhomogeneous distribution and Importance of data sampling, Metropolis algorithm, Brownian motion as random walk problem and its Monte-Carlo simulation.	20

TEXT BOOKS

1. **S. S. M. Wong,** Computational Methods in Physics and Engineering, World Scientific, Singapore, 2nd Edition, 1997.
2. **C. F. Gerald,** Applied Numerical Analysis, Pearson/Addison Wesley, UK, 7th Edition, 2003.
3. **Teukolsky, Vetterling and Flannery,** Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition 2007.
4. **Landau and Binder,** A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge University Press, 3rd Edition, 2013.
5. **V. Rajaraman,** Computer Oriented Numerical Methods, Prentice Hall of India, New Delhi, 4th Edition, 2015.
6. **V. Rajaraman,** Computer Programming in FORTRAN 90/95, Prentice Hall of India, New Delhi, 1st Edition, 2015.

Modern Optics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Modern Optics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 102 GEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. with Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The course has focus on the Geometrical and wave optics, thin films, Holography, optical fiber, liquid crystals, LED and Photonic band gap crystals.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of optics.
• To impart knowledge about different physical phenomena.
• To update the students with the latest technologies.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO102G.1. Understand the various physical phenomena & their real life applications.
CO102G.2. Learn about the wave optics and holography.
CO102G.3. Get knowledge about the basics of Lasers.
CO102G.4. Learn about the fiber optics & LED.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
</table>

1	**An overview of Geometrical and Wave Optics:** Laws of Reflection, Refraction, Total Internal Reflection; Ideas of Interference, Diffraction, Polarization, Dispersion.	15
2	**Fresnel Relations:** Conductors, Thin Films: Reflection Model, Matrix Formalism, Coating Design, Fourier Optics: Wave Propagation, Fraunhofer Diffraction, Fresnel Diffraction, Spatial Filtering, Holography and Holograms.	15
3	**Coherence, Interference and Visibility, Laser Physics:** Overview, Gain Saturation, Light-Atom Interactions, Optical Gain and Pumping Schemes, Output Characteristics, Light Shifts and Optical Forces, Atom-Photon interactions.	15
4	**Fiber Optics:** Mode Analysis, Single mode and multimode optical fiber, Loss and Dispersion, Photonics Band-gap Crystals, Liquid crystals, Introduction of LED.	15

TEXT BOOKS

1. 1. **A. E. Siegman,** Lasers, University Science Book, USA,Revised Edition, 1986.
2. **G. R. Fowles,** Introduction to Modern Optics, Dover Publication, USA, 2^{nd} Edition, 1989.
3. **J. T. Verdeyen,** Laser Electronics, Prentice-Hall, India,New Delhi, 3^{rd} Edition, 1995.
4. **E. Hecht,** Optics, Addison Wesley, USA, 4^{th} Edition, 2001.
5. **Pedrotti,**Introduction to Optics, Pearson UK, 3^{rd} Edition, 2006.
6. **B. E. A. Saleh and M. C. Teich,** Fundamentals of Photonics, Wiley,United States, 2^{nd} Edition, 2012.
7. **A. Ghatak,** Optics, Tata McGraw-Hill, New Delhi, 6^{th} Edition, 2017.

Physics of Digital Photography

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Physics of Digital Photography</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 103 GEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. with Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is to provide a theoretical overview of the photographic imaging chain. The course is intended to serve as a link between imaging science and photographic practice.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To become proficient at the technical aspect of photographing with a digital camera.
• To develop and practice skills using digital photography tools and the Internet including emailing and posting to a web site
• To develop the habit of looking closely at the visible world around you in order to represent it in terms of aesthetics, beauty and truth. – To look at what you are seeing and to see what you are looking at.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
CO103G.1. To understand the photographic optics & methods
CO103G.2. To understand the basic principle of photography
CO103G.3. To understand the theory of exposure
CO103G.4. To understand about the image quality</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Fundamental optical formulae:** Image formation: Refraction, Gaussian optics, Lens refractive power, Magnification, Focal length, Lens focusing movement Field of view: Entrance and exit pupils, Chief and marginal rays, Angular field of view, Field of view area, Focal-length multiplier, Depth of field: Circle of confusion, Depth of field equations, Hyperfocal distance, Focus and recompose limits, distortion, Exposure: Photometry, Flux emitted into a cone, Relative aperture, f-number, Working f-number, f-stop, Natural vignetting, Photometric exposure, Exposure value, f-number for aplanatic lenses	**15**
2	**History of photography:** Pinhole Camera, Camera Obscura, Normal Human Eye and Process of Seeing-Human eye and camera, Camera principles: Compact cameras and SLR's - Working of SLR camera- Different image sensors-CCD and CMOS. Angle of view- Different types of lenses-normal lens, wide angle lens, fish eye lens, prime lens, telephoto lens. Depth of Field-Shallow depth of field, large depth of field, Depth of focus - circles of confusion	**15**
3	**Exposure strategy :** Digital output, Sensor response, Colour, Digital output levels, Dynamic range, Tonal range, Tone reproduction, Gamma, Tone curves, Histograms, verage photometry, Reflected-light metering, Average scene luminance, Exposure index, ISO speed, Standard output sensitivity, Exposure modes: Metering modes, Exposure compensation, Aperture priority (A or Av), Shutter priority (S or Tv), Program mode (P), Manual mode (M)	**15**
4	**Image quality :** Colour temperature, White balance, Color space, Lens MTF, sharpness, Signal-to-noise ratio, Different Image capturing formats: RAW, TIFF, JPEG, Storage Devices- SD card CF card, Principles of Composition: Perspective - Space (Negative and Positive), Directional lines-Golden Section and Rule of the Third, Colour	**15**

	Theory	

TEXT BOOKS

1. **Steven Heller**, A History of Photography: From 1839 to the Present
2. **Tom Ang,** Photography: The Definitive Visual History
3. **Todd Gustavson** and **George Eastman House**, Camera: A History of Photography from Daguerreotype to Digital by Understanding Exposure, Fourth Edition by BRYAN PETERSON.
4. **DK**, Digital Photography Complete Course Hardcover
5. **Fil Hunter, Steven Biver and Paul Fuqua**, Light Science & Magic: An Introduction to Photographic Lighting by Understanding Color in Photography by Bryan Peterson.
6. **Andy Rowland**, Physics of Digital Photography by (IOP Publishing).

RENEWABLE ENERGY RESOURCES

Scheme Version:	Name of the Subject:	L	T	P	C	Semester:	Contact hours per week: 4
2021-2022	Renewable Energy Resources	3	1	0	4	**I** (1st Year)	**Total Hours: 30**
Subject Code: SBS PHY 01 104 GEC 2002	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks):** 100	**CIE**	**30 Marks**	**Examination Duration: 3 hours**		
			TEE	**70 Marks**	**Pre-requisite of course:** 10+2 with Non-Medical		
Course Description	To introduce the pattern of fuel consumption, energy demand, various renewable sources of energy and modern applications.						
Course Objectives	• The course treats the basics of various renewable energy resources and energy generation using different methods; it is suitable for students from interdisciplinary background.						
Course Outcomes:	On completion of this course, student will learn: **CO104G.1** The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues. **CO104G.2** The Course will be introducing the students to all the aspects of PV technology. This will enable them to understand the requirements for PV materials and PV systems for different applications. **CO104G.3** It creates awareness among students about wind and geothermal energy technologies and provide adequate inputs on a variety of issues. **CO104G.4** To teach fundamentals of hydrogen energy as energy systems, production processes, storage, utilization, and safety that is necessary for taking some important elective subjects. **CO104G.5** It increases the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors. **CO104G.6** To give an idea about different biomass and nuclear as energy source and their processing and utilization for recovery of energy and other valuable products. A comprehensive knowledge of how wastes are utilized for recovery of value would be immensely useful for the students from all fields.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1.	**Energy Scenario and Solar Energy:** Global and Indian Energy Scenario and Energy Policy, Commercial and Noncommercial Forms of Energy, Fossil Fuels, Renewable Sources, Impact of Energy Systems on Environment, Need for use of New and Renewable Energy Sources, Solar Thermal and Solar Photovoltaic Energy.	15
2.	**Wind and Geothermal Energy:** Wind Energy Basics- Global circulation, Forces influencing Wind - Pressure gradient force and Coriolis force, Local and Regional Wind systems, Geothermal Tidal and Wave Energy, Geothermal regions, geothermal sources, Geothermal energy conversion technologies.	15

3.	**Hydrogen Energy and Fuel cells:** Hydrogen Energy-production and storage, Production Processes: Thermo chemical Water Splitting, Gasification, Pyrolysis methods. Electrochemical, Electrolysis, Photo electro chemical. General storage methods, compressed storage, Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Fuel cells-Thermodynamics and performance of Fuel Cells, Its working, construction, classifications and applications.	15
4.	**Biomass and Nuclear Energy:** Biomass Energy and application, Techniques for biomass assessment, Thermochemical conversion of biomass, Mini/micro hydro power: classification of hydropower schemes, Nuclear Energy: Fission, Fusion, Different type of nuclear reactors, Nuclear waste disposal and environment measures.	15
REFERENCE BOOKS		

1. Solar Energy: S. P. Sukhatme, (Tata McGraw Hill).
2. Garg .H.P,Prakash .J, “Solar energy fundamentals and applications”, Tata McGraw Hill publishing Co. Ltd, 2006.
3. Xianguo Li, Principles of Fuel Cells, Taylor and Francis, 2005.
4. Fundamentals of Renewable Energy Processes, Aldo Vieira da Rosa, Elsevier Academic Press.
5. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006.
6. KC Khandelwal, SS Mahdi, Biogas Technology - A Practical Handbook, Tata McGraw Hill, 1986.
7. EH Lysen, Introduction to Wind Energy, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983.
8. JG Collier and GF Hewitt, Introduction to Nuclear Power, Hemisphere Publishing, New York, 1987.

STATISTICAL MECHANICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1^{st} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 201 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Quantum Mechanics and Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is developed for understanding of thermodynamics and statistical mechanics, which have broad and rich applicability in quantum mechanics, condensed matter physics, classical mechanics and electrodynamics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of thermodynamics and statistical mechanics

• To make familiar with various thermodynamical and statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.

• To able the students for solve the problems related to thermodynamics and statistical physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to

CO201C.1. explain the various thermodynamical quantities and Maxwell’s relations

CO201C.2 apply the thermodynamics in ideal gas, magnetic and dielectric materials

CO201C.3. describe various statistical approaches which describe systems of particles

CO201C.4. evaluate the formulae of random walk and diffusion equation

CO201C.5. compare microstates, macrostates, and statistical ensembles</td></tr>
</table>

	CO201C.6.understand the theories and mathematical approaches of statistical ensembles, equipartition theorem and Maxwell-Boltzmann statistics **CO201C.7.** illustatre the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics **CO201C.8.** calculate the problems related to Bosons and Fermions	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Review of Thermodynamics:** Extensive and intensive variables, laws of thermodynamics, Entropy for Different Systems, Gibbs Paradox, Boltzmann Relation for Entropy, Legendre Transformations and Thermodynamic Potentials, Chemical Potential, Free Energy and Its Connection with Thermodynamic Quantities, Maxwell Relations, Applications of Thermodynamics to (a) Ideal Gas, (b) Magnetic Material, and (c) Dielectric Material.	15
2	**Statistical Methods and Description of Systems of Particles :** Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem, Random Walk and Brownian Motion, Diffusion Equation, Phase Space, Liouville's Theorem, Phase Equilibrium, Microstates and Macrostates, Statistical Ensembles, Irreversibility and the Attainment of Equilibrium	15
3	**Classical Statistical Mechanics:** Micro-Canonical Ensemble, Canonical Ensemble: Derivation of Partition Function and Thermodynamic Quantities; Mean Values and Fluctuations, Grand Canonical Ensemble: Gibbs Factor; Gibbs Distribution; Derivation of Partition Function and Thermodynamic Quantities; Fluctuations in the Number of Particles, Applications of Canonical and Grand Canonical Ensembles, Equipartition Theorem and It's Applications, Maxwell-Boltzmann Statistics.	15
4	**Quantum Statistical Mechanics:** Bosons: Occupation Number; Bose-Einstein Statistics; Debye Theory of Specific Heat; Grand partition function For Ideal Bose	15

	Gas; Black-Body Radiation; Bose-Einstein Condensation, Fermions: Occupation Number; Fermi-Dirac Statistics; Ideal Fermi gas, Pauli Paramagnetism, First and Second Order Phase Transitions, Ising Model, Phase Equilibria: Equilibrium Conditions; Simple Phase Diagrams; Clausius-Clapeyron Equation.	

TEXT BOOKS

1. **F. Reif**, Fundamental of Statistical and Thermal Physics, McGraw-Hill, USA, 1965.
2. **L. D. Landau and E. M. Lifshitz**, Statistical Physics, UK, 3rd Edition, 1980.
3. **D. V. Schroeder**, An Introduction to Thermal Physics, Addison Wesley Longman, UK, 2000.
4. **J. P. Sethna**, Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford University Press, UK, 2006.
5. **M. Kardar**, Statistical Physics of Particles, Cambridge University Press, UK, 2007.
6. **H. Gould and J. Tobochnik**, Statistical and Thermal Physics: With Computer Applications, Princeton University Press, USA, 2010.
7. **K. Huang**, Statistical Mechanics, Wiley, India, 2nd Edition, 2011.
8. **R. K. Pathria and P. D. Beale**, Statistical Mechanics, Academic Press, USA, 2011.

Classical Electrodynamics

<table>
<tr><td rowspan="2">Scheme Version :

2021-22</td><td rowspan="2">Name of the subject:
Classical Electrodynamics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 202 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc.Physics</td><td rowspan="2">Evaluation
(Total Marks:100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of basic electrodynamics and it’s applications to various phenomena.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To evaluate fields and forces in Electrodynamics and Magneto dynamics using basic scientific method.
• To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
CO202C.1. To understand the basics of electrostatics
CO202C.2. To use of Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.
CO202C.3. To describe the nature of electromagnetic wave and its propagation through different media and interfaces.</td></tr>
</table>

	CO202C.4. The students will be able to analyze s radiation systems in which the electricdipole, magnetic dipole or electric quadruple dominate. **CO202C.5.** The students will have an understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration. **CO202C.6.** To explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Electrostatics :** Coulomb's law, Guass's law, Poisson's equation, Laplace equation. Simple boundary value problems illustrating various techniques such as method of images, separation of variables, Green's functions, Multipole expansion. Electrostatics of dielectric media, multipole expansion. Boundary value problems in dielectrics; molecular polarisability, Clausius Mossotti Relation, electrostatic energy in dielectric media.	**15**
2	**Magnetostatics & Maxwell's Equations:** Review of Magnetostatics: Biot-Savart law, Ampere's theorem, Electromagnetic induction, examples of magnetostatic problems, , Scalar and vector potentials, Singularity in Dipole Field: Fermi Contact term, Gauge symmetry, Coulomb and Lorentz gauges, Hertz Potential, Gauge invariance, Displacement current, Time varying fields, Maxwell's equations in free space and linear isotropic media (non conducting) boundary conditions on the fields at interfaces. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field,	**15**
3	**Electromagnetic Waves:** Electromagnetic waves in free space, dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, Total internal Reflection: Stoke's parameter, interference, coherence, and diffraction, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation	**15**

	modes in wave guides, Resonant Cavities	
4	**Radiation and Relativistic Electrodynamics:** Lorentz Transformation, Lorentz invariance of Maxwell's equation. Dynamics of charged particles in static and uniform electromagnetic fields. Radiation- from moving charges and dipoles and retarded potentials Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, Lienard-Wiechert potentials, Total power radiated by an accelerated charge, Lorentz formula. Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.	**15**

TEXT BOOKS

1. **L.D. Landau** and E.M. Lifshitz, Classical Theory of Electrodynamics, Butterworth-Heinemann. Germany, 4thEdition, 1987.
2. **S.P. Puri** , Classical Electrodynamics, Narosa Publishing House, 2011.
3. **Melvin Schwartz**, Principles of Electrodynamics, Dover Publications, UK, 1st Edition, 1987.
4. **Walter Greiner**, Classical Electrodynamics, Springer, Germany, 1st Edition, 1998.
5. **J. Schwinger**, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J. Norton, Classical Electrodynamics, WestviewPress, UK, 1998.
6. **David J. Griffiths**, Introduction to Electrodynamics, Benjamin Cummings, USA, 3rd Edition, 1999.
7. **J.D. Jackson**, Classical Electrodynamics, John Wiley & Sons, United States, 2nd Edition, 2003.
8. **Charles A. Brau**, Modern Problems in Classical Electrodynamics, Oxford University Press, 1st Edition, 2003.
9. **L. D. Landau** and E. M. Lifshitz & L. P. Pitaevskii, Electrodynamics of Continuous Media Oxford, 1st Edition,2005.
10. **Wolfgang K. H. Panofsky** and Melba Phillips, Classical Electricity and Magnetism, Dover Publications, UK,2nd Edition, 2012.
11. **Joseph Edminister**, Schaum's outline of electromagnetics, New Delhi, 2nd Edition, 2017.

Mathematical Methods in Physics-II

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject: Mathematical Methods in Physics-II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2" colspan="2">Semester:
II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 203 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="4">Prerequisite of Course: Mathematical Methods in Physics I</td></tr>
<tr><td>Course Description</td><td colspan="8">This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different subjects of M.Sc. Physics. It includes Ordinary differential equation, special functions and different transformation methods to solve differential equation.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To Make the students familiar with
• Partial and Ordinary differential equations in Physics.
• Power series method of their solution and different polynomials
• Fourier Transfor and Laplace Transform as a tool to solve differential equation.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">On completion of the course, student would be able to:
CO203C.1 : to solve second order differential equation.
CO203C.2 : to use the special function in Quantum mechanics and electrodynamics
CO203C.3 : to perform Fourier transform on a given data set.
CO203C.4 : to perform Laplace transform on a given data set.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Second Order Differential Equations :
Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre functions as solutions. Orthogonal properties and recurrence relations of these functions.</td><td colspan="2">15</td></tr>
<tr><td>2</td><td colspan="6">Special functions :

Spherical harmonics and associated Legendre polynomials. Sturm -Liouville systems and orthogonal polynomials. Wronskian linear independence and/ linear dependence.</td><td colspan="2">15</td></tr>
</table>

3	**Fourier Transforms:** Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform, Convolution theorem. Simple Applications: FTIR, Telecommunication systems, Solution of partial differential equation wave equation	15
4	**Laplace Transforms:** Laplace transforms and their properties, Convolution theorem, Application of Laplace transform in solving linear, differential equations with constant coefficient, with variable coefficient and linear partial differential equation.	15

TEXT BOOKS

1. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, S. CHAND (Prentice Hall of India), New Delhi, 2nd Edition, 1987.
2. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications, UK, Vol 1 &2, 1970.
3. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press, Cambridge, 7th Edition, 2012.
4. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc. 2014.
5. **E. Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons, United States, 10th Edition, 2015,
6. **K.F.Riley, M.P. Hobson, and S.J.Bence,** Mathematical methods for Physicists and Engineers, S. CHAND (Cambridge University Press), New Delhi, 3rd Edition, 2018.
7. **V Balakrishnan:** Mathematical Physics with Applications, Problems and Solutions; Ane Books, 1st Edition, 2018.

LABORATORY-II

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Laboratory-II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 204 CC 00126</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim & objective of the course is to impart the practical training on various electronics devices such as; Op-Amp, Vibrators, Amplifiers, Michelson interferometer etc. Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To train students for various electronics experiments and take measurements
• To train students on various optical instruments like Spectrometer, Michelson Interferometer
• To have hand on experiment for measurement of magnetoresistance and dielectric constant.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
CO204C.1. Understand spectral lines, grating spectra, and interference fringes
CO204C.2. Learn the characteristics of Op-Amp, vibrators, clipper, clampers, and DA/ AD
CO204C.3. Use excel for plotting graphs
CO204C.4. Understand motion of temperature and magnetic field dependence of Hall</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">coefficient.</td></tr>
<tr><td colspan="3" align="center">COURSE SYLLABUS</td></tr>
<tr><td align="center">Unit No.</td><td align="center">Content of Each Unit</td><td align="center">Hours of Each Unit</td></tr>
<tr><td align="center">1</td><td>1. Study of Balmer series and Rydberg constant
2. Op-Amp as inverting and non-inverting amplifier
3. Op-Amp as differentiator, Integrator and Adder
4. e/m by Thomson method
5. Single stage RC coupled amplifier
6. Frequency response of common emitter amplifier
7. Bistable/Monostable/Astable vibrators
8. Grating spectra
9. Refractive index of water and oil using prism
10. Magneto resistance
11. Temperature dependence of Hall coefficient
12. Digital to Analog converter, Analog to Digital converter
13. Michelson Interferometer
14. Faraday Effect
15. Clipper and clampers</td><td align="center">150</td></tr>
<tr><td align="center">2</td><td>1. Root finding of a polynomial equation using numerical methods
2. Solving first and second order differential equation numerical methods
3. Numerical integration
4. Generating finite and infinite series</td><td align="center">30</td></tr>
<tr><td colspan="3" align="center">TEXT BOOKS</td></tr>
<tr><td colspan="3">2. Worsnop and Flint, Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951.
3. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.
3. Lab manuals, prepared by faculty of the Department of Physics, 2018.</td></tr>
</table>

QUANTUM MECHANICS - II

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Quantum Mechanics – II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 201 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Quantum Mechanics-I</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand some advanced topics such as symmetries, identical particles, approximation methods and relativity in quantum mechanics, which has broad and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To make familiar with various advanced topics of quantum mechanics such as symmetries and conservation laws, fermions and bosons, time independent and time dependent perturbation theories, variational and WKB methods, scattering theory, delta function and relativistic theory
To aware the students about applications of advanced phenomena of quantum mechanics in physical, mathematical and chemical sciences</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students will be able to

CO201D.1. understand the concepts of symmetries, conservation laws, bosons and fermions in quantum mechanics

CO201D.2. apply symmetries and conservation laws in various quantum mechanical problems

CO201D.3. illustatre the time independent and time dependent perturbation theories, the</td></tr>
</table>

	variational and WKB methods **CO201D.4.** describe the fine structure and Zeeman effect phenomena **CO201D.5.** explain the basics of scattering theory **CO201D.6.** apply the delta function's properties in various quantum mechanical problems **CO201D.7.** understand the basics of relativistic quantum mechanics **CO201D.8.** recognize the importance and applications of relativistic quantum mechanics

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Symmetries, Conservation Laws & Identical Particles :** Transformation in space, The Translation Operator, Translation Symmetry, Conservation Laws, Parity: Parity in One & Three Dimensions; Parity Selection Rules, Rotational Symmetry, Degeneracy, Rotational Selection Rules, Many Particle Systems, Systems of Identical Particles, The Helium Atom, The Pauli Exclusion Principle.	15
2	**Approximation Methods [Course Outcome(s):** Time Independent Perturbation Theory: Nondegenerate Perturbation Theory; Degenerate Perturbation Theory; Fine Structure; The Zeeman Effect, The Variational Method, The WKB method, Time Dependent Perturbation Theory, Adiabatic & Sudden Approximations.	15
3	**Scattering Theory & The Delta Function [Course:** Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering, The Delta Function: One Dimensional Delta Function and Three Dimensional Delta Function.	15
4	**Relativistic Quantum Mechanics:** Klein-Gordon equation, Dirac equation, Probability and Current	15

	Density, Plane Wave Solutions, Symmetries of the Dirac equation, Dirac's Equation for a Central Potential, Covariance of Dirac's Equation, Relativistic Hydrogen Atom Problem, The Hole Theory and Positrons.	

TEXT BOOKS

1. **L. D. Landau and E.M. Lifshitz**, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3rd Edition, 1981.
2. **P. A. M. Dirac**, The Principles of Quantum Mechanics, Oxford University Press, UK, 4th Edition, 1988.
3. **R. Shankar**, Principles of Quantum Mechanics, Springer, Germany, 2nd Edition, 1994.
4. **N. Zettili**, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2nd Edition, 2009.
5. **J. J. Sakurai**, Modern Quantum Mechanics, Pearson, India, 2nd Edition, 2013.
6. **L. I. Schiff**, Quantum Mechanics, McGraw Hill Education, USA, 4th Edition, 2017.
7. **D. J. Griffiths**, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3rd Edition, 2018.
8. **C. Cohen-Tannoudji, B. Diu, and F. Laloe**, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2nd Edition, 2019.

Introduction to Astronomy and Astrophysics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Introduction to Astronomy and Astrophysics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 202 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: General Mathematics</td></tr>
<tr><td>Course Description</td><td colspan="7">To make the students aware about different theoretical and observational technique adopted in understanding astrophysics and astronomy</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The objective of this course is to make the students
Understand coordinate systems in Astronomy
Understand the Sun
Understand Binary stars.
Understand stellar distances</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to :
CO202D.1 : differentiate between various coordinate systems
CO202D.2 : know about the characteristics of Sun
CO202D.3 : Know about Binary stars and their motions
CO202D.4 : Know about stellar distances and other properties</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Observational Data:
Astronomical Coordinates- Celestial Sphere, Horizon, Equatorial, Ecliptic and galactic system of coordinates, Conversion from one coordinate system to another. Aspects of sky from different places on the earth. Twilight, Seasons, Sidereal. Apparent and Mean solar time and their relations. Calendar. Julian date and heliocentric correction. Determination of Mass, luminosity, radius, temperature and distance of a star, H-R Diagram, Empirical mass-luminosity relation.</td><td>15</td></tr>
</table>

2	**Stellar Distances and Magnitudes :** Distances of stars from the trigonometric, secular and moving cluster parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magnitudes and distance modulus. Colour index. Black-body approximation to the continuous radiation and temperatures of stars. Variable stars as distance indicators.	15
3	**Binaries and Variable Stars :** Visual, spectroscopic and eclipsing binaries. Importance of binary stars as source of basic astrophysical data. Classification and properties of various types of intrinsic and eruptive variable stars. Astrophysical importance of the study of variable stars. Novae and Supernovae.	15
4	**Sun** : [Course Outcomes : Physical Characteristic of Sun – Basic data, solar rotation, solar magnetic fields, Photosphere- granulation, sun-spots, Babcock model of sunspot formation, solar atmosphere-chromospheres and corona, Solar activity – flares, prominences, Solar wind, activity cycle, Helioseismology	15

TEXT BOOKS

1. **W.M.Smart**: Text book of Spherical Astronomy, Cambridge University Press; 6th edition, 1977
2. **M. Zeilik,** Astronomy, The evolving Universe, Cambridge University Press , 1st Edition, 2002.
3. **P.V. Foukal,** Solar Astrophysics , Wiley-VCH, United States, 1st Edition, 2004.

4. **I. Morrison,** Introduction to Astronomy and Cosmology, Wiley, United States, 1st Edition, 2008

FUNDAMENTALS OF SOLAR ENERGY

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:

Fundamentals of Solar Energy</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact hours per week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 01 203 DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course: There is no prerequisite or co-requisite for this course. But students are expected to know basic semiconductor physics.</td></tr>
<tr><td>Course Description</td><td colspan="7">The course is intended for students who have interest in alternate energy sources as a contributor to sustainability. It provides a comprehensive treatise on the science and technology of solar energy, its collection and the design principles that need to be understood for its effective use in a variety of installations and uses.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• The Course will be introducing the students to all the aspects of PV technology.
• To develop basic understanding related to fabrication ad characterization of different types of solar cells.
• To know state of art in the field of solar cells materials and solar cells.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO203.1 The available solar energy and the current solar energy conversion and utilization processes, solar spectrum.

CO203.2 The factors that influence the use of solar radiation as an energy source.

CO203.3 The various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.

CO203.4 How solar cells convert light into electricity, how solar cells are manufactured, how solar cells are evaluated.

CO203.5 What technologies are currently on the market, and how to evaluate the risk</td></tr>
</table>

	and potential of existing and emerging solar cell technologies. **CO203.6** To examine the potential & drawbacks of currently manufactured technologies, as well as pre-commercial technologies. How to enhance solar cell performance and reduce cost, and the major hurdles-technological and economic, towards widespread adoption.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**Solar Radiation:** origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, sun tracking systems, photo thermal conversion, solar energy collectors, collector efficiency and its dependence on various parameters.	15
2.	**Solar energy:** storage of solar energy, solar pond, solar water heater, solar distillation, solar cooker, solar green houses, solar dryers, absorption air conditioning. solar fuels: electrolysis of water, photoelectrochemical splitting of water.	15
3.	**Fundamentals of solar cells:** Photo voltaic effect, semiconductor properties, energy levels, basic equations, p-n junction its characteristics, fabrication steps, thermal equilibrium condition, depletion capacitance, junction breakdown, heterojunction. Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells.	15
4.	**Device physics**: Solar cell device structures, construction, output power, efficiency, fill factor and optimization for maximum power, surface structures for maximum light absorption, current voltage characteristics in dark and light, operating temperature vs conversion efficiency, charge carrier generation, recombination and other losses. Cadmium telluride solar cells, copper indium gallium selenide solar	15

	cells, organic solar cells, perovskite solar cells, Advanced concepts in photovoltaic research.	

REFERENCE BOOKS

1. S P Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 1996.
2. Solid State Electronic Devices, Ben. G. Streetman, S. K. Banerjee, PHI Leaning Pvt. Ltd, 2000.
3. D. Yogi Goswami, Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, Taylor and Francis, 2000.
4. Jasprit Singh, Semiconductor Devices, Basic Principles, Wiley, 2001
5. Stephen J.Fonash, Solar Cell Device Physics, 2nd edition, Academic Press, 2003.
6. H P Garg, J Prakash, Solar energy fundamentals and applications, Tata McGraw Hill publishing Co. Ltd, 2006.

Accelerator Physics

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Accelerator Physics	3	1	0	4	II (1st Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 204 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Nuclear Physics, Electrodynamics, Quantum mechanics		
Course Description	This course is intended to expose the students to theoretical design and usage of various particle accelerators.						
Course Objectives	• To understand the beam optics. • Get knowledge about different types of accelerators • To understand the main features of superconducting cyclotron, linear accelerators and high energy accelerators.						
Course Outcomes	After completion of this course, students would be able to: **CO204D.1.** Understand the beam optics & beam transport system. **CO204D.2.** About various theoretical techniques to accelerate particles and technical details of electrostatic accelerators. **CO204D.3.** Get knowledge about latest accelerator technology based on Rf cavities. **CO204D.4.** About Synchrotron Radiations & production of radioactive ion beams.						

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Charged Particle Dynamics:** Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.	15
2	**Electrostatic and Heavy Ion Accelerators:** Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams.	15
3	**Radiofrequency Accelerators:** Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs, Superconducting Heavy Ion Linear Accelerators. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.	15
4	**Synchrotron Radiation Sources:** Electromagnetic radiation from relativistic electron beams, Electron synchrotron, Characteristics of synchrotron radiation. Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators.	15

TEXT BOOKS

1. **M.S. Livingston and J.P. Blewel**, Particle Accelerators, McGraw-Hill Book Press, 1962.

2. **Ed. J. Cerny**, Nuclear Spectroscopy and Reactions Part-A, Academic Press, 1974.

3. **H.J. Wiedman**, Particle Accelerator Physics, Vol I and II, Springer Verlag, 1998.

4. **S. Y. Lee**, Accelerator Physics, World Scientific, Singapore, 2004

Radiation Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Radiation Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 205 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Nuclear Physics, Electrodynamics, Quantum mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart knowledge in depth about nuclear radiation, its detection, nuclear spectrometry and related aspects</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To aware the students about the various type of nuclear radiations and their interaction with matter
To learn various techniques for detection of radiations
To study the nuclear spectrometry</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:

CO205D.1. Understand nuclear radiation and its detection procedure, nuclear spectrometry.
CO205D.2. Know applications of nuclear spectrometry

CO205D.3. Know how to solve problems related to safety aspect of nuclear radiation

CO205D.4 Understand the nuclear spectroscopy and basics of nuclear medicine.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Interaction of Nuclear Radiations:** Origin and energy spectra, Brief discussion of interactions of gamma rays, Electron and heavy charged particles with matter, Different types of neutron sources, Interaction of neutron with matter, Neutron detectors.	15
2	**Nuclear Radiation Detector:** Gas filled detectors; Ionization chamber, Proportional counter and GM counter, Scintillation detector, semiconductor detector for X-rays, gamma rays and charged particle detection, Radiation exposure, Biological effects of radiation, radiation monitoring	15
3	**Nuclear Spectrometry and Applications:** Analysis of nuclear spectrometric data, measurement of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, measurement of g-factor and hyperfine fields.	15
4	**Mossbauer Effect:** Positron annihilation, particle and photon induced x-ray emission, Elemental concentration analysis by charged particles and neutron activation analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.	15

TEXT BOOKS

1. Knoll G. F., Radiation Detection and Measurement, John Wiley & Sons, 1989.
2. Singuru R. M., Introduction to experimental nuclear physics, Wiley Eastern Publications, 1987.
3. Muraleedhara V. Nuclear radiation Detection, measurement and Analysis, Narosa Publishing House, 2009.

Computational Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Computational Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 206 DCEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the course is to train the students for various computational techniques to solve integration, differentiation and molecular dynamics simulation techniques.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To train students for computer programming
• To make students familiar with simulation techniques
• To train students for executing many body problems related computer programs</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

• computations techniques to solve various differential equations
• the computational integration
• the molecular simulations and optimization techniques.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Stochastic Processes:** Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.	**15**

2	**Numerical Integration and Stochastic Differential Equations:** Dynamical equations, Finite Difference Method, Langevin dynamics, TDGL equation, Cahn-Hilliard equation, Burgers' equation, KPZ model, Traffic Flow Dynamics.	**15**
3	**Molecular Dynamics (MD) and Monte Carlo (MC) Simulations:** Elementary ideas of molecular dynamics simulation, Physical potentials, Verlet algorithm. Time average and Ensemble average, Monte Carlo methods, Metropolis algorithm. Application of Monte-carlo simulations: (a) Ising model in magnetism (b) Glauber and Kawasaki dynamics.	**15**
4	**Combinatorial Optimization Problems:** Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique. **Computational experiments using computer programming** 1. Finite and infinite series 2. Root finding: (bisection, Secant and Newton-Raphson methods), 3. Solving first and second order ordinary differential equations including simultaneous, equations (Euler and Runge-Kutta methods) 4. Numerical integration (trapezoidal, Simpson, Gauss quadrature, methods) 5. Matrices (arrays of variable sizes, addition, multiplication, eigenvalues, eigenvectors, inversion, solutions of simultaneous equations) 6. To determine Wien's constant using bisection method and false position method. 7. To solve Kepler's equation by Newton-Raphson method. 8. To solve van der Waals gas equation for volume of a real gas by the method of successive approximation. 9. To interpolate a real data set from an experiment using the Lagrange's method, and Newton's method of forward differences and cubic splines. 10. To fit the Einstein's photoelectric equation to a	**15**

	realistic data set and hence calculate Planck's constant. To estimate the value of π by rectangular method, Simpson rule and Gauss quadrature by numerically evaluating suitable integral. 11. To find the area of a unit circle by Monte Carlo integration. 12. To simulate Buffen's needle experiment. 13. To simulate the random walk. 14. To study the motion of an artificial satellite by solving Newton's equation for its orbit using Euler method. 15. To study the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method, and to draw graphs between current and time in each case. 16. To study the motion of two coupled harmonic oscillators.	

TEXT BOOKS

1. **V. Rajaraman,** Computer Oriented Numerical Methods, Prentice Hall of India, 3rd Edition, 1993.

2. **V. Rajaraman,** Computer Programming in FORTRAN 90/95, Prentice Hall of India, 1st Edition,1997.

3. **D. Frenkel & B. Smit,** Understanding Molecular Simulation, Academic Press,2nd Edition,2001.

4. **M. Plischke & B. Bergersen,** Equilibrium Statistical Physics, World Scientific, 3rd Edition, 2006.

1. **W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,** Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.
2. **M. P. Allen,** Computer Simulation of Liquids, Oxford University Press,2nd Edition , 2017**.**

3. **Kurt Binder and Heerman,** Monte Carlo Simulation in Statistical Physics,Springer,6th Edition,2019.

Analog Electronics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Analog Electronics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 207 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course covers the design, construction, and operation of analog electronic circuits. The main contents are: the basic principles of operation, terminal characteristics, and equivalent circuit models for diodes, transistors, and op-amps. Frequency response of cascaded amplifiers and gain-bandwidth considerations. Concepts of feedback, stability and frequency compensation.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To introduce students to entire circuit designs
• To provide in-depth theoretical base of Digital Electronics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
CO207D.1. To understand the techniques to shape of signals.
CO207D.2 To understand the principle of multivibrators
CO207D.3 To understand basic properties of analog systems
CO207D.4 To understand the fundamental designing concepts of different types of Logic Gates, Minimization techniques etc.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Linear Wave Shaping :**	**15**

	High Pass RC circuits: Its response to step, Pulse, Square wave, Ramp, exponential waveforms, Low pass RC Circuit: Its response to step, pulse, Square wave, Ramp, Exponential wave forms, Its application as an integrator. Attenuators, Time base Signal in a CRO. Operation of Clamping Circuits, Clamping Circuit theorem, Practical Clamping Circuit theorem, Operation of Transistor as a switch. **Clipping and Switching Circuits:** Diode Clippers, Combinational and Biased clippers Transistor Clippers, Comparators, Applications of Voltage Comparators.	
2	**Multivibrators :** A bistable multivibrator-basic concepts of its operation. Symmetrical and Unsymmetrical triggering, Application (brief). Monostable Multivibrator, Basic concepts of its operation, quantitative discussion of Quasi stable state, Application, Astable multivibrator - basic concepts of operation. Quantitative discussion of the period of oscillation, Application.	**15**
3	**Analog Systems**: Operational Amplifier, Differential Amplifier, Transfer Characteristics, Frequency Characteristics, IC Operational Amplifier, Compensation in Operational Amplifiers, Application of OP-AMP as adder, Multiplier, Differentiator, Integrator, Log and Antilog Amplifier, Application of Operational Amplifier to analogue computation.	**15**
4	**Logic Systems**: Basic Concepts of dc positive and negative logic systems, Dynamic logic systems, OR gate and AND gate, NOT gate, NAND gate, EX-OR gate, NOR gate & their applications, Response to input pulse operation. TTL (transistor transistor logic) and DTL (diode transistor logic) logics Binary Adders, Half adders and full adders, Multiplexing and demultiplexing.	**15**

TEXT BOOKS

1. **P. Horowitz and W. Hill,** The Art of Electronics, Cambridge University Press, 2nd Edition, 1989.
2. **J.J. Cathey,** Schaum's Outline of Electronic Devices and Circuits, McGraw Hill Education, New York, 2nd Edition, 2002.
3. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, New Delhi, 8th Edition 2003.
4. **A.P. Malvino**, Electronic Principles, Tata McGraw, New Delhi, 7th Edition, 2009.
5. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Cambridge University Press, 4th Edition 2009.

6. **W. Kleitz**, Digital Electronics, A Practical Approach, Pearson, UK, 9th Edition 2011.
7. **R. J. Tocci**, Digital Systems-Principles and Applications, Prentice Hall of India, New Delhi, 10th Edition 2013.
8. **Millman and Halkias**, Integrated Electronics, McGraw Hill, New York, 2nd Edition, 2017.

Environmental Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Environmental Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 201 GEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: 10+2 with Science</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce students to the application of core physical concepts of the Earth system, with special focus on: atmospheric radiation, greenhouse gases, pollution, and climate change. This course will demonstrate how physics is fundamental to understand natural and human influences on climate and atmospheric composition.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To understand the broad scope of problems to which the principles of environmental physics can be applied and to appreciate the commonalities that exist among widely varying systems;

• To develop problem solving abilities and a critical, practical awareness of global environmental change.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO202G.1. To understand the concepts like energy transformations and various forms of energy, climate change and its effect on living beings

CO202G.2. To understand the concepts like thermodynamics and its applications to various energy transformation processes:

CO202G.3. To develop an awareness of climate change and its effects

CO202G.4. To develop an awareness of different fossil fuels and their alternatives</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit

1	**Introduction to Energy:** Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.	**15**
2	**Heat Energy and Kinetic Theory** Heat and Tem:perature. Internal Energy, Specific Heat. Ideal gas equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation. Heat engines and the second law of thermodynamics. The Carnot cycle. Applications of the second law to various energy transformation processes: heat pumps and refrigerators; different engine cycles. Entropy and disorder.	**15**
3	**Energy and Climate Change:** Energy balance of the Earth. Greenhouse effect. Climate feedbacks (water, clouds, ice albedo). Global Climate Models. Evidence for climate change. Paleo-climate. Climate change impacts. Climate change mitigation. Target CO_2 levels.	**15**
4	**Energy Source [Course Outcome(s):** Chemical energy. Energy in biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas). Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels. Alternative energy resource: Wind energy, energy from water on land, ocean energy. Biomass and other sources.	

TEXT BOOKS

1. **Sol Wieder**, An Introduction of Solar Energy for scientists and Engineers, John Wiley, United States, 1st Edition, 1982.
2. **J.T. Widell** and **J. Weir**, Renewable Energy Resources, Elbs, 1st Edition, 1988.
3. **R.N. Keshavamurthy** and **M. Shankar Rao**, The Physics of Monsoons, Allied Publishers, New Delhi, 1st Edition, 1992.
4. **Landau** & **Lifshitz**, Fluid Mechanics, Pergamon Press, UK, 2nd Edition, 2000.
5. **Egbert Boeker** & **Rienk Van Groundelle**, Environmental Physics, John Wiley, United States, 2nd Edition, 2000.
6. **J.T. Hougtyion**, The Physics of Atmosphere, Cambridge University Press, 3rd Edition, 2002.
7. **C. W. Rose**, An Introduction to the Environmental Physics of Soil, Water and Watersheds, Cambridge University Press, 1st Edition, 2004.
8. **R. A. Hinrichs** and **M. Kleinbach**, Energy, Its Use and the Environment, Brooks Cole, Stanford University Press, 4th Edition, 2005.

9. **P. Hughes**, **N. J. Mason**, Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor & Francis, France, 1st Edition, 2005.
10. **J. Monteith** and **M. Unsworth**, Principles of Environmental Physics: Plants, Animals and the Atmosphere, Elsevier, 4th Edition, Europe, 2013.
11. **K.L. Kumar**, Engineering Fluid Mechanics, S. Chand, New Delhi, 4th Edition, 2016.

Latex for Humans

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Latex for Humans</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 2</td></tr>
<tr><td>1</td><td>0</td><td>2</td><td>2</td><td>Total Hours: 30</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 202 GEC 1022</td><td rowspan="2">Applicable to Programs: All Masters/ Bachelors Program</td><td rowspan="2">Evaluation (Total Marks: 50)</td><td>CIE</td><td>15 Marks</td><td colspan="3">Examination Duration: 2 hours</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite: 10+2 with Non-Medical</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart knowledge to student about different tools used in writing scientific/non-scientific literature.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Write beautifully presentable documents using Latex.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to:
CO202G.1 :Write CV, documents, books and reports.
CO202G.2 : Write mathematical formulae using simple commands.
CO202G.3 : Produce fonts in different languages like Roman and Greek.
CO202G.4 : Write Thesis and seminar presentations using latex
CO202G.5 : Tell the advantages of LaTeX over other more traditional softwares.
CO202G.6 : install and use MikTeX.
CO202G.7 : List LaTeX compatible operating systems.
CO202G.8 : Explain how to obtain LaTeX</td></tr>
</table>

<table>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>Software installation, Markup Languages</td><td>5</td></tr>
<tr><td>2</td><td>LATEX typesetting basics, LATEX math typesetting</td><td>10</td></tr>
<tr><td>3</td><td>Tables and matrices, Graphics, Packages, User definable packages</td><td>7</td></tr>
<tr><td>4</td><td></td><td>8</td></tr>
</table>

	Document classes, text bibTEX, beamer, flash cards / CV, Creating your own package, Project.	
Text Books		
1. **Helmut Kopka & Patrick W. Daly,**Guide to LATEX, Addison-Wesley, New Delhi, 4th Edition 2003. 2. **Stefan Kottwitz** , LaTeX Beginner's Guide, Packt Publishing, UK. 1st Edition, 2011 3. Resources from websites: The not so short introduction to LaTeX - Tobi Oetiker *https://tobi.oetiker.ch/lshort/lshort.pdf*		

Atomic, Molecular Physics and Lasers

Scheme Version: 2021-22	Name of the subject: Atomic, Molecular Physics and Lasers	L	T	P	C	Semester: III (2^{nd} Year)	Contact Hours per Week: 4
		3	1	0	4		Total Hours: 60
Subject Code: SBS **PHY 01 301 CC 3104**	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I, Statistical Mechanics**		

Course Description	Aim of the course is to aware students about various atomic and molecular spectra and to understand the working of LASERs.
Course Objectives	The students will be exposed to . Rotation and Vibration spectroscopy . Raman Effect and Raman spectroscopy of molecules. . Working of Lasers
Course Outcomes	On completion of the course, student would be able to : **CO301C.1 :** Understand different models of an Atom **CO301C.2 :** derive the energy distribution corresponding to different levels of an atom **CO301C.3 :** Understand rotation spectroscopy and Understand Raman Effect and Raman spectroscopy of molecules. **CO301C.4 :** understand the working of He-Ne Laser and Ruby Laser.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Atomic Spectra I:** Review of Atomic Models: Rutherford’s Model, Bohr’s model, Sommerfeld’s model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect.	15

2	**Atomic Spectra II:** Spin-orbit interaction and fine structure, LS and JJ coupling, Relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the hydrogen atom spectra, Zeeman and Paschen-Back effect. Hyperfine structure and isotope shift, Auger Effect and Frank Condon Principle. Born-Oppenheimer approximation.	15
3	**Molecular spectra:** Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, Vi vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy (Brief Introduction).	15
4	**Lasers:** Spontaneous and stimulated emission, Spatial and temporal Coherence, Einstein A and B coefficients, Optical Pumping, Population Inversion, Modes of resonator, Q-switching and Mode Locking, Ultra short pulse generation, He-Ne Laser and Ruby Laser- Principle, Construction and working, Application of lasers in the field of medicine and Industry.	15

Text Books

1. **H. E. White,** Introduction to Atomic Spectra, McGraw Hill, New York, 1st Edition, 1934.
2. **H. G. Kuhn,** Introduction to Atomic Spectra, Green and Co., Harlow, 2nd Edition, 1969.
3. **K. Thyagarajan and A.K. Ghatak,** Lasers - Theory and Applications, Plenum Press, New York, 1st Edition, 1981.
4. **B. H.Bransden and C. J Joachain,** Physics of Atoms and Molecules, Pearson, UK, 2nd Edition, 2003.
5. **R. Eisberg and R. Resnick,** Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, United States, 2nd Edition, 2006.
6. **Arthur Beiser,** Perspectives of Modern Physics, McGraw Hill, New York, 6th Edition, 2006.
7. **C. N. Banwell,** Fundamentals of Molecular Spectroscopy, McGraw Hill, New York, 4th Edition, 2017.

NUCLEAR PHYSICS

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Nuclear and Particle Physics	3	1	0	4	III (2nd Year)	Total Hours: 60
Subject Code: SBS PHY 01 302 CC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Quantum Mechanics		
Course Description	This course will enable the M.Sc. students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions. They will also learn about the elementary particle physics.						
Course Objectives	Students will be exposed to • General properties of nuclei • Interactions among the nucleons • Different models developed to explain the nuclear structure • Elementary classification of particles and their properties						
Course Outcomes	After completion of this course, the students will be able to **CO302C.1.** Understand basic properties of nuclei **CO302C.2.** Understand interactions between nucleons, meson theory and spin dependence of nuclear forces **CO302C.3.** Get knowledge about Nuclear models, Magic numbers, and Collective nuclear model. Elementary knowledge about classification of particles. **CO302C.4.** Classify the particles and will be able to understand their properties.						

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introductory Concept of Nuclei:** Scattering and electromagnetic methods for determining the nuclear radius, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Nuclear Disintegration: Simple theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.	15
2	**Inter Nucleon Forces:** Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.	15
3	**Nuclear Structure and Models:** Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular moment, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi-empirical mass formula, Nuclear fission, The unified model.	15
4	**Particle Physics:** Properties and origin, Elementary particles, Properties, classification, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell-Mann-Okubu mass formula.	15
TEXT BOOKS		

1. **Roy & Nigam,**Nuclear Physics, John Wiley & Sons, USA, 1st Edition, 1967.
2. **H. Enge,**Introduction to nuclear Physics, Addison Wesley, USA, 1st Edition 1969.
3. **J.M. Blatt and V.F. Weisskopf,** Theoretical Nuclear Physics, Springer, Germany, 1st Edition, 1969.
4. **M.Leon,**Particle Physics:An introduction, Elsevier, Netherlands, 1st Edition, 1973.
5. **S. N. Ghoshal**, Nuclear Physics, S. Chand, India, 1st Edition, 1994.
6. **F.I. Stancu,** Group Theory in Subnuclear Physics, Clarendon Press, UK, 1st Edition, 1997.
7. **J.D. Walecka,**Theoretical Nuclear and Subnuclear Physics, World Scientific, Singapore, 2nd Edition, 2004.
8. **B. R. Martin and G. Shaw,**Particle Physics, John Wiley & Sons, USA, 3rd Edition, 2008.

SOLID STATE PHYSICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Solid State Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 303 CC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Graduation Level Solid State Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">The solid state physics is the branch of physics dealing with physical properties of solids particularly crystals, including the behavior of electrons in these solids. The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.

• To develop the scientific and positive attitudes in students related to the materials science which is a part of solid state physics

• To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to

CO303C.1. identify various crystal structures and their symmetries in solids

CO303C.2. determine the crystal structure through X-ray diffraction, rotating crystal, and Laue methods

CO303C.3. explain the theories and phenomena of lattice dynamics, various bonding, and</td></tr>
</table>

	thermal properties (specifically specific heat) in solids **CO303C.4.** calculate the specific heat and density of states of various solids **CO303C.5.** interpret the electrical conductivity and resistivity, mean free path, relaxation time, Fermi energy, electronic specific heat, and band formation in solids **CO303C.6.** recognize the importance of effective mass, nearly free-electron model and tight binding approximation **CO303C.7.** identify the basic differences between conductors and superconductors **CO303C.8.** illustrate the some exciting phenomena such as Meissner effect, Isotope effect, London's equations, BCS theory, and Josephson effect of superconductors **CO303C.9.** understand the basics of high temperature superconductors and commercial applications of superconductors	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Crystal Structure:** Crystal Structures and Lattices with Basis, Miller Indices, Common Crystal Structures, Reciprocal Lattice, Brillouin Zones, X-ray Diffraction by a Crystal and Their Equivalence, Laue Equations, Ewald Construction, Brillouin Interpretation, Intensity of X-ray Reflections: Atomic Scattering Factor; Geometrical Structure Factor, Structure Factors, Structure Factor; Experimental Methods of Structure Analysis: Laue's Method; Rotating Crystal Method; Powder Method, Diffraction from Non-Crystalline Systems.	15
2	**Lattice Dynamics, Crystal Binding and Thermal Properties:** Classical Theory of Lattice Dynamics: Vibrations of Crystals with Monatomic Basis and Two Atomic Basis; Dispersion Relation; Group Velocity; Acoustical and Optical modes, Bonding in Solids, Elastic Constants and Properties, Phonons: Quantization of Lattice Vibration; Phonon Momentum; Inelastic Scattering of Neutrons by	15

	Phonons, Thermal Properties: Heat Capacity; Density of States; Normal Modes; Debye and Einstein Models.	
3	**Free Electrons and Energy Band in Solids:** Free Electron Gas Model and Its Limitations, Electrons Moving in One and Three Dimensional Potential Well, The Density of States, Fermi Energy, Effect of Temperature on Fermi Distribution Function, The Electronic Specific Heat, The Electrical Conductivity of Metals, Relaxation Time and Mean Free Path, The Electrical Resistivity, Band Theory: Bloch Theorem; The Kronig-Penny Model; Symmetry Properties of the Energy Function; Effective Mass of an Electron; The Nearly Free Electron Model and Tight Binding Approximation; Metals; Insulators and Semiconductors.	15
4	**Superconductivity:** Introduction to Superconductivity, Effect of Magnetic Field, The Meissner Effect, Type I and Type II Superconductors, Entropy, Free Energy, Heat Capacity, Energy gap, Isotope Effect, Thermodynamics of the Superconducting Transition, London Equation and Penetration Depth, Coherence Length, BCS Theory of Superconductivity, Cooper Pair, Flux Quantization, DC and AC Josephson Effects: SQUIDs, High Temperature Superconductivity, Applications of Superconductors.	15

TEXT BOOKS

1. **J. M. Ziman**, Principles of the Theory of Solids, Cambridge University Press, UK, 2nd Edition, 1979.
2. **J. F. Annett**, Superconductivity Super fluids and Condensates, Oxford University Press, UK, 1st Edition, 2004.
3. **J. P. Srivastava**, Elements of Solid State Physics, Prentice-Hall of India, 2nd Edition, 2006.
4. **H. Ibach and H. Luth**, Solid State Physics: An Introduction to Theory and Experiment, Springer, Germany, 4th Edition, 2009.
5. **M. A. Wahab**, Solid State Physics: Structure and Properties of Materials, Narosa Publications, India, 2nd Edition, 2009.
6. **C. Kittel**, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. **N. W. Ashcroft and N. D. Mermin**, Solid State Physics, Holt, Rinehart and Winston, USA, Revised Edition, 2016.
8. **S. O. Pillai,** Solid State Physics, New Age International Publishers, 8th Edition, 2018.

LABORATORY-III

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Laboratory-III</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2^{nd} Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 304 CC 00126</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of Lab III is to train students for advanced practical related to solid state physics, nuclear physics, electronics, numerical techniques and material science.

Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To train students on advanced experiments
• To give training on advance instruments
• To introduce students to latest numerical techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to

CO304C.1. Apart from some experiments based on nuclear physics, electronics, computation and solid state physics.

CO304C.2. To understand the basic synthesis and characterization techniques for different materials such as thin films and nanoparticles.

CO304C.3. students will also perform the advance experiments like DTA, TGA, UV-VIS, Microwave furnace and thin film coating techniques.</td></tr>
</table>

	CO204C.4. Students will advance techniques of numerical analysis

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	1. Kerr Effect 2. Curie Temperature 3. B-H curve 4. Dielectric constant 5. Solid State Nuclear Track Detector (SSNTD) 6. G.M. Counters: characteristics, dead time and counting statistics 7. Scintillation detector-energy calibration, resolution and determination of gamma ray energy 8. Quinks tube method to find susceptibility of a material 9. Nuclear Magnetic Resonance 10. Zeeman Effect 11. To study Lattice Dynamics	100
2	**(i) Electronics** 1. PCM/delta modulation and demodulation 2. Fiber optic communication 3. Modulation/Demodulation 4. 4-bit ripple counter **(ii) Thin Film and Nano-Material** 1. Data Analysis of XRD, SEM and TEM 2. Chemical Deposition (for CNT growth) 3. ZnO wire by thermal oxidation 4. Band gap estimation by Tauc-plot method 5. Thin film deposition technique 6. DTA/TGA analysis **(iii) Numerical Techniques** 1. Solution of Linear algebraic equation: Gauss Jordon elimination, Singular Value Decomposition, Sparse linear system. 2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function. 3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness. 4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data.	80

	5. Eigen systems: Solving eigenvalues and finding eigen functions of Schrodinger equation for analytically unsolvable potentials using variational principle.	

TEXT BOOKS

1. Albert Malvino, Digital Principles and Applications, McGraw Hill, New York, 4th Edition, 1986.

2. **A. C. Melissinos, J. Napolitano,** Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.

3.**W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,** Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.

4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, and Complexity, Oxford University Press, 2nd Edition, 2007.

5. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1st Edition, 2017.

SEMINAR PRESENTATION

Scheme Version:	Name of the subject:		L	T	P	C	Semester:	Contact Hours per Week:
2021-22	SEMINAR PRESENTATION		0	2	0	2	II (2nd Year)	**Total Hours:**
Subject Code: SBS PHY 01 305 CC 2002	**Applicable to Programs:** M.Sc. Physics		**Evaluation (Total Marks : 50)**	CIE	15	**Examination Duration:** 20 Minutes		
				TEE	35 Marks	**Prerequisite of Course:** None		
Course Description		The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.						
Course Objectives		• To make students familiar with approach to do literature survey • To make student capable of independent thinking • Students will learn basic techniques for carrying out research						
Course Outcomes		After completion of this project, students will be able to learn about: **CO305.1.** Basic of literature review **CO305.2.** Techniques used for performing research **CO305.3.** Analyze the results and tabulate them in a proper manner **CO305.4.** How to write and dissertation, making presentation and viva etc.						

Evaluation: The evaluation will be done internal committee constituted by Head of the Department. Internal marks will be given by the mentor allotted to each candidate.

Research and Publication Ethics

Scheme Version:	Name of the subject:		L	T	P	C	Semester:	Contact Hours per Week: 2
2021-22	Research and Publication Ethics		2	0	0	2	III (2nd Year)	Total Hours: 30
Subject Code: SBS PHY 01 306 CC 2002	Applicable to Programs: M.Sc. Physics		Evaluation (Total Marks : 50)	CIE	15 Marks	Examination Duration: 1.5 Hours		
				TEE	35 Marks	Prerequisite of Course: None		

Course Description		The objective of the course is to familiarize the students with ethics of research and how to make publications
Course Objectives		• To train student for research • To make students aware of IPR policy
Course Outcomes		On completion of the course, the student should be able to: **CO306D.1**: Understand the basic ethics of research. **CO306D.2**: Maintain the research integrity and intellectual honesty. **CO306D.3:** Understand the scientific misconduct and proper citations. **CO306D.4**: Acquire knowledge of databases and software's.

COURSE SYLLABUS

Unit No.		Content of Each Unit	Hours of Each Unit
1		**Theory:** RPE 01: Philosophy and Ethics (3 hrs.)	15

		1. Introduction to philosophy: definition, concept, branches, nature and scope, 2. Ethics: definition, moral philosophy, nature of moral judgements and reactions RPE 02: Scientific Conduct (5 hrs.) 1. Ethics with respect to science and research 2. Intellectual honesty and research integrity 3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) 4. Redundant publications: duplicate and overlapping publications, salami slicing 5. Selective reporting and misrepresentation of data RPE 03: Publication Ethics (7 hrs.) 1. Publication ethics: definition, introduction and importance 2. Best practices/standards setting initiatives and guidance: COPE, WAME, etc. 3. Conflicts of interest 4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types 5. Violation of publication ethics, authorship and contribution-ship 6. Identification of publication misconduct, complaints and appeals 7. Predatory publishers and journals	
2		Practice: RPE 04: Open Access Publishing (4 hrs.) 1. Open access publications and initiatives 2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices 3. Software tool to identify predatory publications developed by SPPU 4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc. RPE 05: Publication Misconduct (4 hrs.) *A. Group Discussion (2 hrs.)* 1. Subject specific ethical issues, FFP, authorship 2. Conflicts of interest 3. Complaints and appeals: examples and fraud from India and abroad	15

		B. Software tools (2 hrs.) 1. Use of plagiarism software like Turnitin, Urkund and other open source software tools RPE 06: Databases and Research Metrics (7 hrs.) *A. Databases (4 hrs.)* 1. Indexing databases Research Metrics 2. Citation databases: Web of Science, Scopus, etc. *B. Research Metrics (3 hrs.)* 1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score 2. Metrics: h index, g index, i10 index, almetrics	

TEXT BOOKS

1. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance, 2019, ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

2. Chaddah, P., Ethics in Competitive Research: Do not get scooped; do not get plagiarized 2018, ISBN:978-9387480865.
3. Beall, J. Predatory publishers are corrupting open access, Nature, 489 (7415), 179-179, 2012. https://doi.org/10.1038/489179a

4. Resnik, D. B., What is ethics in research and why is it important, National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm 2011.

5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A Guide to Responsible Conduct in Research: 3rd edition , National Academics Press 2009. Bird, A., Philosophy of Science, Routledge 2006.
6. MacIntyre, A., A Short History of Ethics, London 1967.

Physics of Electronic Material and Devices

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Physics of Electronic Material and Devices</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (2^{nd} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 301 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course intends to provide knowledge about band structure and electronic properties of semiconducting materials. In addition, this course aims to provide a detailed theory and design of electronic, microwave and photonics devices.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To acquire the fundamental knowledge and expose to the field of semiconductor theory and devices and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO301D.1. To describe the properties of materials and application of semiconductor electronics

CO301D.2. To understand the oncepts of recombination and generations of charge carriers

CO301D.3. To understand basic properties of Metal-Semiconductor junction.

CO301D.4. To understand the working, design and applications of various semiconducting devices like rectifiers, clippers, LED, Solar cells.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours

		of Each Unit
1	**Fundamentals of Semiconductors:** Carrier concentration of semiconductor, Transport Equations, Fundamentals of Compound Semiconductors: Introduction of Compound Semiconductors, Properties of Compound semiconductors, Synthesis of Compound Semiconductors. Crystal structures of Elemental and III-IV	**15**
2	**Carrier mobility in semiconductors:** Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Shockley read theory of recombination, Switching in electronic devices.	**15**
3	**Metal-semiconductor, Metal-Insulator-Semiconductor and MOS devices:** Native oxides of Compound semiconductors for MOS devices and the interface state density related issues. Metal semiconductor contacts, Schottky barrier diode, Metal semiconductor Field Effect Transistors (MESFETs): Pinch off voltage and threshold voltage of MESFETs. D.C. characteristics and analysis of drain current. Velocity overshoot effects and the related advantages of GaAs, InP and GaN based devices for high speed operation. Sub threshold characteristics, short channel effects and the performance of scaled down devices.	**15**
4	**High Frequency Devices:** Essential Condition of High frequency device and compound semiconductor,Tunnel diode, MIS Tunnel diode, Degenerate and Non-degenerate semiconductor, MIS switch diode, MIM Tunnel diode. IMPATT diode. Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred electron devices. Photonic devices: LED and LASER, Photo detectors, Solar-cells.	**15**

TEXT BOOKS

1. **A.S. Grove**, Physics and Technology of Semiconductor Devices, WILEY, United States, 1st Edition , 1967.
2. **B.L. Sharma,Metal**, Semiconductor Schottky Barrier Junction and their Applications, Springer, USA, 1st Edition, 1984.
3. **E. H.Rhoderick**, Metal/Semicond uctor Contacts, Clarendon Press, UK, 1st Edition , 1988.
4. **Jasprit Singh**, Semiconductor Devices Basic Principles, John Wiley & Sons, United States, 1st Edition, 2000.
5. **S.M. Sze**, Physics of Semiconductor Devices, John Wiley & Sons, United States, 2nd Edition, 2003.

Nuclear Reactor Physics

<table>
<tr><td rowspan="2">Scheme Version :
2021-22</td><td rowspan="2">Name of the subject:
Nuclear Reactor Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 302 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to impart primary but wide theoretical knowledge about nuclear reactor and related topics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the theoretical and experimental knowledge about nuclear reactors.
• To know about the basic designs of nuclear reactors.
• To understand the need of nuclear fuel and waste management.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO302D.1. Understand the nuclear fission reactions.
CO302D.2. Learn about neutron sources and moderators.
CO302D.3. Get knowledge about working of nuclear reactors.
CO302D.4. Get knowledge about different types of power reactors
CO302D.5. Learn how to manage the nuclear fuel and waste.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Nuclear Reactions:** Characteristics of atomic nucleus, Binding energy, Nuclear fission, Cross section, Interaction of neutrons with nuclei.	15
2	**Neutron moderation**: Inelastic scattering, Elastic collisions, Moderating ratio, Slowing down Density, Resonance escape, Moderators, Neutron sources, Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.	15
3	**Nuclear Reactors:** Fuel materials, Moderator materials, Cladding materials, Coolant materials and control materials, Control requirement calculations, Means of control, Reactor kinematics: Neutron lifetime, Generation time, Point kinetic equation and solution of the equations for step input reactivity.	15
4	**Types of Power reactors & Fuel and waste management:** Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.	15
Laboratory Assignments: Visits to fission reactor sites and related case studies for generation of nuclear energy.		
TEXT BOOKS		

1. **Lamarshs, J.R.**, Introduction to Nuclear Reactor Theory, Addison-Wesley Publishing Co., 1966.
2. **Glasstons**, Sammuel and Sesonske, Alexander, Nuclear reactor Engineer, CBS Publishers & Distributors, 1986.

PLASMA PHYSICS AND FUSION REACTOR

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Plasma Physics and Fusion Reactor</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 303 DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Mathematical Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">Students will be exposed to theory related to motion of charge particle in inhomogeneous field, production of plasma and usage of plasma.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To make students familiar with fourth state of matter
• To aware students about plasma creation in laboratory
• To make students familiar with production of energy in fusion reactor</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will have understanding of

CO303D.1. what are theoretical method to study the charge particle motion
CO303D.2 Idea behind the magnetic confinement
CO303D.3. how to generate plasma in the laboratory
CO303D.4. how plasma production is helpful to make fusion reactors</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Introduction:</td><td>15</td></tr>
</table>

	Plasma state, plasma parameters, applications of plasmas. **Single particle orbit theory:** Drift of charge particle under different combinations of electric and magnetic field, crossed electric and magnetic fields, homogenous electric and magnetic fields, spatially and time varying electric and magnetic fields,	
2	**The Boltzmann Equation:** Simplified magneto-hydrodynamic equations - Electron plasma oscillations Debye shielding phenomenon and criteria for plasma, motion of charged particles in electromagnetic field, Electric field drift, parallel acceleration, curvature drift, adiabatic invariants; fundamental equations of magneto-hydrodynamics(MHD), magnetic confinement.	15
3	**Production of Plasma in laboratory:** Physics of glow discharge, electron emission, ionization breakdown of gases, Paschen's law and different regimes of E/ρ in a discharge. **Plasma diagnostic:** Probes, energy analysers, magnetic probes and optical diagnostics, preliminary concepts.	15
4	**Fusion Reactor**: Potential of fusion energy, controlled thermonuclear reactions, fusion reactions, fusion cross-sections, fusion power generation, energy balance for fusion systems, ignition criterion, gain factor, plasma heating, ohmic heating, neutral beam injection, radio frequency heating, inertial confinement fusion, tokamaks, stability, operating limits and transport.	15

TEXT BOOKS

1. Nicholson, D. R., Introduction to Plasma theory, Wiley, 1983
2. Chen, F.F., Introduction to Plasma Physics, Springer, 1984
3. Sturrock, P.A., Plasma Astrophysics, Cambridge University Press, 1994
4. Choudhuri, A.R., The Physics of Fluids and Plasmas, Cambridge University Press, 1998

PHYSICS OF NANOMATERIALS

Scheme Version:	Name of the Subject:	L	T	P	C	Semester:	Contact hours per week: 4
2021-2022	Physics of Nanomaterials	3	1	0	4	III(2ndYear)	Total Hours: 60
Subject Code: SBS PHY 01 304 DCEC 3104	Applicable to Programs: M.Sc. Physics	Evaluation (Total Marks): 100	CIE	30 Marks	Examination Duration: 3 hours		
			TEE	70 Marks	Pre-requisite of course: Solid State Physics		
Course Description	To introduce knowledge on basics of nanoscience and the fundamental concepts behind size reduction in various physical properties. More specifically, the student will be able to understand the different properties of materials being used in various length scales.						
Course Objectives	• The objective of this course is to provide the knowledge on the Physics of nanostructure materials, materials growth aspects important for size control and size selection and application of nanoscale materials. • The course lays foundation for advanced courses in engineering aspects of materials and their applications.						
Course Outcomes:	On completion of this course, student will learn: **CO304.1** Correlate properties of nanostructures with their size, shape and surface characteristics. **CO304.2** Qualitatively describe how the nanoparticle size can affect the morphology, crystal structure, reactivity, and mechanical properties. **CO304.3** Understand the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale. **CO304.4** Describe several synthesis methods for fabrication of inorganic nanoparticles, one-dimensional nanostructures (nanotubes, nanorods, nanowires), thin films, nonporous materials, and nanostructured bulk materials, and also could describe how different lithography methods can be used for making nanostructures. **CO304.5** Understand some specific materials like graphene and carbon nanotubes for various						

	applications. **CO304.6** To comprehend basic knowledge on the characterization of nanomaterials by different methods.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**Introduction to Nanostructure Materials:** Nanoscience & nanotechnology, size dependence of properties, Chemical-reactivity, Mechanical properties at nanoscale, Moor's law, Surface energy and Melting point (quasi melting) of nanoparticles, Excitons, Density of states, Variation of density of states with energy and size of crystal. Population of conduction and valance band for 0D, 1D, 2D & 3D material.	15
2.	**Quantum Size Effect:** Quantum confinement and its consequences, quantum wells, quantum wires and quantum dots and artificial atoms. Electronic structure from bulk to quantum dot. Electron states in direct and indirect gap semiconductors nanocrystals. Confinement in disordered and amorphous systems.	15
3.	**Synthesis of Nanomaterials:** Key issue in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Thermal and e-beam evaporation, Gas phase synthesis of nanopowders, chemical and colloidal methods, sol gel method, functionalization of nanoparticles. Ball Milling, Specific materials like graphene and carbon nanotubes (CNTs).	15
4.	**Characterization techniques:** XRD (Scherrer's formula), Electron Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Raman Spectroscopy and XPS, Estimation of band gap using UV-Vis-NIR spectroscopy, Thermogravimetric analysis.	15
REFERENCE BOOKS		

1. D. Bimberg, M. Grundmann, N.N. Ledenstov, Quantum Dot Hetrostructures, John Wiley & Sons, United States, 1st Edition, 1999.
2. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, United States, 1st Edition, 2003.
3. Guozhong Cao, Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press, UK, 1st Edition, 2004
4. Liming Dai, Carbon Nanotechnology, Elsevier, Netherland, 1st Edition, 2006.
5. Michael J. O'Connell, Carbon Nanotubes: Properties and Applications, CRC Press, USA, 1st Edition, 2006.
6. T. Pradeep, Nano: The Essentials, McGraw Hill Companies, New York, 1st Edition, 2007.
7. Hornyak G.L., Tibbals H.F., Dutta J.,Moore J.J., Introduction to Nanoscience and Nanotechnology, CRC Press, USA, 1st Edition, 2008.

General Theory of Relativity

Scheme Version: 2021-22	Name of the subject: General Theory of Relativity	L	T	P	C	Semester: III(2nd Year)	Contact Hours per Week: 4
		3	1	0	4		**Total Hours:** 60
Subject Code: SBS **PHY 01 305 DCEC 3104**	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Classical Electrodynamics, Mathematical Methods in Physics I & II**		

Course Description	Aim of the course is to familiarize students with different aspects of theory of gravitation.
Course Objectives	The student will come to understand . Special Theory of Relativity . General Theory of Relativity . Few applications of Geeral Theory of Relativity.
Course Outcomes	On completion of the course, student would be able to **CO305D.1 :** understand the mathematical rigour that goes behind the theory of relativity and also be able to **CO305D.2 :** Understand few applications of general theory of relativity. **CO305D.3 :** Understand the Special theory of relativity **CO305D.4 :** Understand the origin of gravitational waves

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Historical Background:** Review of Newtonian Mechanics. Special theory of relativity. Prelude to General relativity, historical developments, 4-Vectors and 4-tensors, examples from physics	15
2	**Tensors in GTR:** Principle of Equivalence, Equations of motion, Gravitational force, Tensor Analysis in Riemannian space, Effects of Gravitation, Riemann-Christoffel curvature tensor, Ricci Tensor, Curvature Scalar	15
3	**Applications of GTR:** Einstein Field Equations, Experimental tests of General	15

	Theory of Relativity, Scwartzchild Solution, Gravitational lensing	
4	**Gravitational Radiation:** Gravitational waves: generation and detection, Energy, momentum and angular momentum in Gravitation	15

Text Books

1. **S. Weinberg,** Cosmology, Oxford University, 1 st Edition, 2008.
2. **Ray D'Inverno**, Introducing Einstein's General Relativity, Oxford University, 1 st Edition, 1992.
3. **M. Berry,** Principle of Cosmology and Gravitation, Taylor & Francis; 1 st Edition, 1989.
4. **Tai L. Chow**, Introduction to General theory of Relativity and Cosmology, Springer, 1 st Edition, 2008.
5. **P.A.M. Dirac**, General theory of Relativity, Wiley-Blackwell, 1 st Edition, 1975.
6. **L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Publishere, Shroff, 2 nd Edition, 2010**

Astrophysics of Stars

Scheme Version: 2021-22	**Name of the subject: Astrophysics of Stars**	**L**	**T**	**P**	**C**	**Semester:** III(^{2nd} Year)	**Contact Hours per Week:** 4
		3	1	0	4		**Total Hours:** 60
Subject Code: SBS **PHY 01 306 DCEC 3104**	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Introduction to Astronomy and Astrophysics**		
Course Description	Aim of the Course : Stars are the fundamental building blocks of the Universe. By injecting vast amounts of energy and momentum into their surround-ings, they act as drivers for the evolution of their host galaxies..						
Course Objectives	Aim of this course is to understand in detail what goes on deep inside an object that, to us, is a mere pinprick of light in the sky.						
Course Outcomes	On completion of the course, student would be able to **CO306D.1 :** quantify the basic parameters of stars. **CO306D.2 :** understand how radiation interacts with matter at the surfaces of stars **CO306D.3 :** Understand how to produce the spectra that we observe **CO306D.4 :** know about the processes that determine the interior structure, composition and evolution of stars.						

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Stellar Observations** : Introduction, Distance & magnitude, Blackbody radiation, Colors & line spectra, Binary systems : visual binaries, Eclipsing & spectroscopic binaries, The Hertzsprung-Russel diagram, Spectral classification	15
2	**Stellar Atmospheres** : Stellar atmospheres, Describing radiation, Radiation & matter , Radiative transfer, The Eddington approximation, The grey atmosphere, Realistic model atmospheres, Opacity sources, Spectral features, Profile shapes, Line strengths	15

3	**Stellar Interiors :** Mechanical structure, The virial theorem, Polytropes, Equation of state, Energy conservation; diffusive transport, Mass-luminosity relation; main sequences, Convective transport, Energy generation, Nuclear fusion networks, Fusion rates, Rotation, Stellar model building	15
4	**Stellar Evolution** : The main sequence, The Sun, Massive stars, Star formation, Pre-main-sequence evolution, Evolution off the main sequence, Helium burning & beyond, Stellar death, Stellar pulsation, White dwarfs, Neutron stars	15

Text Books

1. "An Introduction to Modern Stellar Astrophysics" ,
Bradley W Carroll and Dale A Ostlie (ISBN: 978-08053034830), Cambridge University Press (2017)
2. "Stellar Structure and Evolution", R. Kippenhahn & A. Weiger, (2012) Springer-Verlag Berlin Heidelberg
3. Structure and Evolution of the Stars, by M. Schwarzschild. (ISBN : 9780691652832), 2016, Princton University Press
4. Stellar Atmospheres, by Ivan Hubeny , Springer Verlag
5. Radiative Processes in Astrophysics : G. Rybiki and A. Lightmann, 2004 WILEY-VCH Verlag GmbH & Co.

Characterization Techniques for Materials

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Characterization Techniques for Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 307 DCEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course covers the fundamental principles and practical applications of different classes of materials and characterization techniques. The course discusses characterization techniques used for chemical and structural analysis of materials, including metals, ceramics, polymers, composites, and semiconductors. The topics include important spectroscopic, microscopic and thermal methods for materials characterization.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To introduce the materials characterization techniques to the students
• Help the students to understand the instrumentation aspects
• To provide a detailed understanding of data interpretation
• To provide hands on experience of the characterization techniques</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO307D.1. To determine crystal structure of specimen and estimate its crystallite size and stress

CO307D.2. To choose an appropriate microscopy techniques to investigate microstructure of materials at high resolution

CO307D.3. To use appropriate spectroscopic technique to measure vibrational/electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.

CO307D.4. To apply thermal analysis techniques to determine thermal stability of</td></tr>
</table>

	and thermodynamic transitions of the specimen.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Structure analysis** X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Phase identification, indexing and lattice parameter determination, Powder X-ray diffractometer. Applications of XRD in bulk and nano-materials.	**15**
2	**Microscopy techniques:** Introduction to Microscopes, Optical microscopy, Transmission Electron Microscopy (TEM); Basic Electron scattering, Concepts of resolution, TEM instruments, Various imaging modes, Analysis of micrographs, Electron Energy Loss Spectroscopy, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (AFM and STM)	**15**
3	**Spectrophotometric analysis of materials [Course Outcome(s):** UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron Spectroscopy (XPS).	**15**
4	**Thermal analysis techniques:** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA), **Electrical characterization techniques:** Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance	**15**

TEXT BOOKS

1. **Wendlandt, W.W.,** Thermal Analysis, John Wiley & Sons, 1986.
2. **Wachtman, J.B.,** Kalman, Z.H., Characterization of Materials, Butterworth Heinemann, 1993.
3. **Murphy, Douglas B,** Fundamentals of Light Microscopy and Electronic Imaging,

Wiley-Liss, Inc. USA, 2000.

4. **Cullity, B.D.,** and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, 2001.
5. **B. Raj**, **T. Jayakumar**, **M. Thavasimuthu**, Practical Non-Destructive Testing, 2nd ed., Narosa Publishing House, 2002.
6. **D. A. Skoog**, **F.J. Holler**, **S. R. Crouch**, Instrumental Analysis, Cengage Learning, 2007.
7. **Li Lin**, **Ashok Kumar**, Materials Characterization Techniques Sam Zhang; CRC Press, 2008.
8. **Y. Leng**, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
9. **J. C. Vickerman**, **I. Gilmore**, Surface Analysis: The Principal Techniques, 2 nd ed., John Wiley & Sons, Inc.2009.

Digital Electronics and Microprocessor

<table>
<tr><td rowspan="2">Scheme Version :
2021-22</td><td rowspan="2">Name of the subject:
Digital Electronics and Microprocessor</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 308 DCEC 3024</td><td rowspan="2">Applicable to Programs:M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Physics of Semiconductor Devices, Analog Electronics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to train the M.Sc students for digital systems, their implementation and application of microprocessor.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of digital systems.
• To make familiar with various logic families and their implementation in logic circuits.
• To understand the design of microprocessors and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students will be able to learn about:
CO308D.1. The basics of digital systems and Boolean algebra.
CO308D.2. Digital arithmetic operations and combinational & sequential circuits.
CO308D.3. Various memory devices & their applications.
CO308D.4. Microprocessor and its various operations.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each</td></tr>
</table>

		Unit
1	**Digital Systems:** Digital signals, binary number system, conversions, Boolean algebra, logic gates, standard gate assemblies, implementing circuits from boolean expressions, SOP, POS, Simplifying logic circuits: algebraic method, K-mapping, Error detection: Parity method, checksum method.	15
2	**Digital Circuits**: Combinational Circuits: Half Adder, Full Adder, Decoder, Encoder, Multiplexer, Demultiplexer and their applications. Sequential Circuits: Flip flops; SR, T, D and J-K, Shift Register, Parallel and Serial data transfer, Timming Waveforms. Counters: Synchronous and Asynchronous Up, Down, and Bidirectional Counters, Timing Wave forms. Digital to Analog Converters and their properties, weighted resistor and R-2R Ladder type, Analog to digital Converters: Flash, Successive approximation, Sigma- Delta ADC.	15
3	**Applications:** Memory: Read Only Memory (ROM): PROM, EPROM, EEPROM, Applications, Programming a ROM, Random Access Memory(RAM): SRAM, DRAM, Applications, Memory Storage cell, Read and Write operations, Programmable Logic Devices (PLD) Digital Display, Seven segment display.	15
4	**8085 Microprocessor:** Basics of Microprocessor-8085, PIN description, Microprocessor initiated operations. Internal data operations. Introduction to 8085 assembly language programming. 8085 instruction, Microprocessor Applications, Recent trends in Microprocessor Technology.	15

Laboratory Assignments:

To construct logic gates OR, AND, NOT, NOR, NAND gates using discrete components and verify their truth tables
To construct logic gates AND, NOT, EX-NOR and EX-OR using NAND gates and verify their truth tables.
To perform 4 bit DAC and ADC operations
To arrange a data set in ascending order using 8080 microprocessor.
Use the IC555 chip as astable, bistable and monostable multivibrator.
To study various operations of Arithmetic logic Unit (ALU).
To perform the addition and subtraction of n 8 bit numbers using 8085 microprocessor
To perform the multiplication and division of two 8 bit number using 8085 microprocessor
To write a program to arrange an array of data in ascending order using 8085 microprocessor
To design and construct multiplexer and demultiplexer and verify their truth tables.

To study the encoders and decoders To perform BCD to Binary operation using 8085 microprocessor.
TEXT BOOKS
1. **Malvino A.P**. and **Brown A**., Digital Computer Electronics, Prentice-Hall, India, New Delhi, 3rd Edition, 1999. 2. **Gaonkar R. S**., Microprocessor Architecture, Programming and Applications, Prentice-Hall, India,New Delhi, 2nd Edition, 2014. 3. **Tocci R. J**., Digital Systems-Principles and Applications, Prentice Hall of India, New Delhi, 8th Edition, 2015.

Programming with Python

Scheme Version:	Name of the subject:		L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Programming with Python		3	0	2	4	III (2^{nd} Year)	Total Hours: 60
Subject Code: SBS PHY 01 309 DCEC 3024	**Applicable to Programs:** M.Sc. Physics		**Evaluation (Total Marks : 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
				TEE	70 Marks	**Prerequisite of Course:** Basic knowledge of computer		
Course Description		The objective of the course on Computational Methods is to familiarize the students about various computational techniques by using Python.						
Course Objectives		• To train student in scientific language Python • To make students comfortable with code writing techniques • To apply numerical methods using Python language						
Course Outcomes		After completion of this course, students will be able to learn about: **CO309D.1.** Learn the basics of programming using Python as a scientific programming language. **CO309D.2.** Understand the basics of input and output formatting and display techniques along with graphical user interface **CO309D.3.** Design algorithms for various numerical methods using Python and **CO309D.4.** Solve selected problems using Python algorithms and programming.						
	COURSE SYLLABUS							
Unit No.		**Content of Each Unit**						**Hours of Each Unit**

1		**Basic of Python:** Computational modeling, python programming for a Physicist, structure of a python program, running python program in console and in editor. constant and variables, numbers-integers, long integer, floating point number, complex number, sequences-string, list, tuples, dictionaries, operators – arithmetic operators, relational operators.	15
2		**Logical Statements**: logical operators, assignment operators, conditional operator. Control statements if, if else, if-elif-else, while, for loop, nested if and nested for loops, break and continue.	15
3		**Functions in Python:** user made, library, inbuilt. Functions definition and declaration, passing arguments, return values, default values and optional parameters. Importing modules, File handling operation with files, opening and closing a file. Formatting inputs and outputs, visualizing data, 2D, 3D, scatter graphs, animating graphs, statistical analysis of data- mean, median, mode, variance**.**	15
4		**Selected Problem using Python:** Optimization: designing an algorithm for accuracy, designing an algorithm for speed, Errors in computation and Numerical stability , numerical integration, differentiation. Curve fitting, least squares method principle, Fourier Transform, symbolic computation, numerical computation.	15
	TEXT BOOKS		
2.	3. Patil P. B. &Verma U. P., Numerical Computational Methods, Revised Edition (Reprint 2013), Narosa Publication. 4. Fangohr H., Introduction to Python for Computational Science and Engineering (A beginner's guide), (2015), Faculty of Engineering and the Environment, University of Southampton. 5. Rajaraman V., Computer Oriented Numerical methods, 3rd Edition (2015), Prentice Hall India Ltd.		

Major Research Project

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Major Research Project</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2nd Year)</td><td>Contact Hours per Week:</td></tr>
<tr><td></td><td>0</td><td>0</td><td></td><td>16</td><td>Total Hours:</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 401 DCEC 00016</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td></td><td rowspan="2">Evaluation
(Total Marks : 400)</td><td>CIE</td><td>120</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td></td><td>TEE</td><td>280
Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="8">The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">• To make students familiar with approach to do literature survey
• To make student capable of independent thinking
• Students will learn basic techniques for carrying out research</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After completion of this project, students will be able to learn about:

CO401.1. Basic of literature review
CO401.2. Techniques used for performing research
CO401.3. Analyze the results and tabulate them in a proper manner
CO401.4. How to write and dissertation, making presentation and viva etc.</td></tr>
</table>

Evaluation: The evaluation will be done by an external examiner. External examiner will award the grades based on quality of research work done recorded in dissertation and presentation made by student.

ADVANCED NULEAR PHYSICS

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Advanced Nuclear Physics	3	1	0	4	IV (2^{nd} Year)	**Total Hours:** 60

Subject Code:	Applicable to Programs:	Evaluation (Total Marks: 100)			
SBS PHY 01 401 DCEC 3104	M.Sc. Physics		**CIE**	30 Marks	**Examination Duration:** 3 hours
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Nuclear Physics

Course Description	To impart knowledge about nuclear deformations, properties and nuclear models for understanding of related reaction dynamics. Beside this students will be exposed to heavy ion physics and nuclear astrophysics.
Course Objectives	• Students will understand about the stability of nuclei away from the drip line and deformed nuclei • Students will know the different theoretical approaches to explain the structure of nuclei • Student will understand the basics of heavy ion nuclear physics and its correlation to Astrophysics
Course Outcomes	After competitions of this course, the students will be able to **CO401D.1.** Know the basic properties of deformed shapes of nuclei **CO401D.2**. Understand the nuclear models to study the nuclear structure properties **CO401D.3.** Understand the various aspects of heavy ion collisions nuclear astrophysics **CO401D.4.** Understand the nuclear astrophysics and related applications.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit

1	**Nuclear deformations:** Effect of quadrupole deformations and higher multipole deformations, Nuclear orientation effect, static and dynamic deformations, deformed magic shells and related nuclear aspects, Importance of Exotic nuclear systems, halo shapes and bubble effect.	15
2	**Collective Model of Nucleus:** Collective motion, parameterization of nuclear surface, Rotation of deformed nuclei, Collective model Hamiltonian, nuclear wave function for even-even nuclei and odd-A nuclei, Rotation-vibrational coupling, Nilsson model, Cranking shell model.	15
3	**Heavy-Ion Physics:** Total Hamiltonian function, Scattering of deformed nuclei, Fusion fission dynamics, Radioactive ion beams, tightly and loosely bound interactions, Nuclear isomers, Nuclear Molecules, Nuclear Dynamics at Intermediate and high energies, Relativistic heavy ion collisions	15
4	**Nuclear Astrophysics:** Hot big bang cosmology, Primordial nucleosynthesis, Stellar nucleosynthesis, energy production in stars, pp chain, CNO cycle, production of elements. **Nuclear Applications**: Recent trends in nuclear structure physics and related important applications	15

TEXT BOOKS

1. Pal, M.K., Theory of Nuclear Structure, East-West Press Delhi, 1983.
2. Preston M. A. and Bhaduri R. K., Structure of Nucleus Addison-Wesley, 2000.
3. Lilley J.S., Nuclear physics principles and applications John Wiley & sons Ltd., 2007.
4. Krane K.S. Nuclear Physics, Wiley India Pvt. Ltd., 2008.

PARTICLE PHYSICS

Scheme Version: 2021-22	Name of the subject: Particle Physics	L	T	P	C	Semester: IV (2nd Year)	Contact Hours per Week: 4
		3	1	0	4		Total Hours: 60
Subject Code: SBS PHY 01 402 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Quantum Mechanics, Nuclear Physics		
Course Description	To impart the knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.						
Course Objectives	• Students will understand the different type of particles and interactions among them • Students will be able to understand the conservation laws in particle physics • Students will get to know the production cross section for particles • Students will understand the quark model.						
Course Outcomes	After completion of this course, the students will be able to **CO402D.1.** Need of standard model and its limitations and the properties of QCD. **CO402D.2.** Basic rules of Feynman diagrams and the quark model for hadrons **CO402D.3.** Properties of neutrons and protons in terms of a simple quark model **CO402D.4.** . Weak interaction between quarks and how that this is responsible for β decay. **CO402D.5** Leptons and how the(electron) neutrinos and (electron) antineutrinos are produced during β+ and β- decays respectively						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of

		Each Unit
1	**Introduction:** Fermions and bosons, Particles and antiparticles, Quarks and leptons, Interactions and fields in particle physics, Classical and quantum pictures, Yukawa picture, Types of interactions - electromagnetic, weak, strong and gravitational, units.	15
2	**Invariance Principles and Conservation Laws:** Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem.	15
3	**Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy.	15
4	**Static Quark model of Hadrons:** The Eightfold way, Meson nonet, Baryon octet, Baryon Decuplet, hypothesis of quarks, SU (3) symmetry, Quark spin and color, Quark-antiquark combinations. **Weak Interactions:** Classification of weak interactions, Fermi theory, Weinberg-Salam model, Parity non-conservation in β-decay, Helicity of neutrino, Experimental verification of parity violation, K-decay.	15

TEXT BOOKS

1. Perkins, D.H., Introduction to High Energy Physics, Cambridge University Press, 2000, 3rd ed.
2. Hughes, I.S., Elementary Particles, Cambridge University Press, 1991.
3. Close, F.E., Introduction to Quarks and Partons, Academic Press, 1979.
4. Segre, E., Nuclei and Particles, Benjamin-Cummings, 1977.
5. Khanna, M.P., Introduction to Particle Physics, Prentice-Hall of India, 2004.

Cosmology

Scheme Version: 2021-22	Name of the subject: Cosmology	L	T	P	C	Semester: IV(2nd Year)	Contact Hours per Week: 4
		3	1	0	4		**Total Hours:** 60
Subject Code: SBS **PHY 01 403 DCEC 3104**	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite: Introduction to Astronomy and Astrophysics**		
Course Description	**Cosmology** is a branch of astronomy that involves the origin and evolution of the universe, from the Big Bang to today and on into the future.						
Course Objectives	The aim of this course is to introduce the model of the universe on large scales						
Course Outcomes	On completion of the course, student would be able to **CO403D.1 :** Understand the concepts of STR and GTR **CO403D.2 :** Apply the concepts of GTR to cosmology **CO403D.3 :** Understand the model of expanding universe **CO403D.4 :** Explain the model of early universe and its thermal history.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Principles of Relativity:** Overview of Special Relativity - spacetime interval and Lorentz metric- four vectors - Introduction to general relativity (GR) - equivalence principle - notions of curvature	15
2	**Gravitation as a manifestation of the curvature of spacetime :** gravitational redshift and clock corrections - orbits in strong gravity, light bending and gravitational lensing - concept of horizon and ergosphere, hydrostatic equilibrium in GR - gravitational radiation.	15
3	**Cosmological Models:** Universe at large scales – Homogeneity and isotropy – distance ladder –Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble's law -	15

	Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes.	
4	**Physical Cosmology and Early Universe:** Thermal History of the Universe - distribution functions in the early Universe – relativistic and nonrelativistic limits - Decoupling of neutrinos and the relic neutrino background - Nucleosynthesis - Decoupling of matter and radiation – Cosmic microwave background radiation (CMB)- Anisotropies in CMB - Inflation – Origin and growth of Density Perturbations - Formation of galaxies and large scale structures - Accelerating universe and type-Ia supernovae - The Intergalactic medium and reionization.	15

Text Books

1. Cosmological Physics, Cambridge University Press, J . A. Peacock

2. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010

3. Theoretical Astrophysics, Volume III: Galaxies and Cosmology,
T. Padmanabhan,Cambridge University Press, 2002 (for lectures on Cosmology)

4. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994 (For more material on General Relativity).

5. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology).

6. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity).

7. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995 (for material on Cosmology and Structure formation).

FERROELECTRICITY AND MAGNETISM

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Ferroelectricity and Magnetism</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2^{nd} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 404 DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Solid-State Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to convey the understanding about dielectric, ferroelectric, and magnetic materials, which possess several breakthrough applications in actuators, sensors, energy storage devices, data storage devices etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of dielectric, ferroelectric and magnetism phenomenon in solids
• To make acquainted with several types of electric and magnetic materials and their exciting properties
• To aware the students about industrial applications of ferroelectric and magnetic materials
• To develop the positive and scientific attitudes and analytical thinking in the students related to materials science</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After competitions of this course, the students will be able to

CO404D.1. explain the dielectric phenomenon in crystals with their exciting properties

CO404D.2. interpret the theory of polarization and components of polarizability of polar
dielectrics</td></tr>
</table>

	CO404D.3. learn the basics of ferroelectric and piezoelectric crystals **CO404D.4.** understand the applications of ferroelectric and piezoelectric materials in various electronic devices **CO404D.5.** describe the diamagnetism and paramagnetism phenomenon in solids, specifically the magnetic susceptibility behavior with temperature **CO404D.6.** evaluate the paramagnetic susceptibility of iron group ions, rare earth ions,and conduction electrons **CO404D.7.** compare the general mechanism of ferro, ferri, and anti-ferro magnetic materials **CO404D.8.** recognize some new ferromagnetic materials which possess intriguing applications in data storage devices

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Theory of Dielectrics:** Introduction, The Microscopic Concept of Polarization, Langevin's Theory of Polarization in Polar Dielectrics, Internal-Field or Local Field, Clausius-Mossotti Relation, Components of Polarizability: Electronic Polarizability; Ionic Polarizability; Orientational Polarizability; Total Polarizability, Measurement of Dielectric Constant, Dielectric Losses, Optical Phenomena.	15
2	**Ferroelectric Crystals:** Representative Crystal Types of Ferroelectrics: Properties of Rochelle Salt and Barium Titanate, Ferroelectric Displacive Transitions, Landau Theory of Phase Transition: Second-Order Transitions; First-Order Transitions, Antiferroelectricity, Ferroelectric Domains, Piezoelectricity, Electrostriction, Applications of Ferroelectric Crystals.	15
3	**Diamagnetism and Paramagnetism :** Langevin's Theory of Diamagnetism, Quantum Theory of	15

	Diamagnetism: Mononuclear Systems, Langevin's Theory of Paramagnetism, Quantum Theory of Paramagnetism: Rare Earth Ions; Hund Rule; Iron Group Ions; Crystal Field Splitting, Van Vleck Paramagnetism, Nuclear Paramagnetism, Cooling by Adiabatic Demagnetization, Paramagnetic Susceptibility of Conduction Electrons.	
4	**Ferromagnetism and Antiferromagnetism :** Ferromagnetic Order: Weiss Theory of Ferromagnetism; The Exchange Interaction; The Heisenberg Model, Ferrimagnetic Order: Curie Temperature and Susceptibility of Ferrimagnets, Antiferromagnetic Order, Ferroelectric Domains: Anisotropy Energy; The Bloch Wall; Origin of Domains; Coercivity and Hysteresis, Spin Waves: Magnons in Ferromagnets; The Bloch $T^{3/2}$ Law, Determination of Magnetically Ordered Structures, Some New Magnetic Materials: GMR-CMR Effects.	15

TEXT BOOKS

1. **S. Blundell**, Magnetism in Condensed Matter, Oxford, UK, 1st Edition, 2001.
2. **M.E. Lines and A. M. Glass**, Principles and Applications of Ferroelectrics and Related Materials, Oxford University Press, UK, 2001.
3. **M. A. Omar**, Elementary Solid State Physics, Pearson, India, 1st Edition, 2002.
4. **B. D. Culity and C. D. Grahim**, Introduction to Magnetic Materials, Wiley, USA, 2nd Edition, 2008.
5. **K. Uchino**, Ferroelectric Devices, CRC Press publication, Taylor and Francis Group, 2nd Edition, 2010.
6. **C. Kittel**, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. **M. P. Marder**, Condensed Matter Physics, Wiley, USA, 2nd Edition, 2015.

Advanced Carbon Materials

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Advanced Carbon Materials</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 405 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce students to the advanced carbon material that includes graphene, fullerenes, hierarchical carbon, and CNTs are referred to as strength of revolution and advancement in the era of material science and technology. In general, 20th century corresponds to plastic meanwhile 21st century will be named as “Century of Graphene” owing to its exceptional physical properties.</td></tr>
<tr><td>Course Objective</td><td colspan="7">On completion of the course, student would be able:
To understand various properties of Graphene, CNTs and Fullerenes</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
CO405D.1. To understand the basic properties of carbon
CO405D.2.To understand the various properties and applications of graphene
CO405D.3.To understand the various properties and applications of CNT
CO405D.4.To understand the various properties and applications of fullerenes</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**INTRODUCTION**: Carbon atomic structure and hybridization, carbon on the Earth and	**15**

	in outer space, carbon in technology and economy, carbon isotopes: classification of carbon allotropes, conversion of one allotropic form into another, phase diagram of carbon, new carbon structures: discovery of C_{60}, Graphene and Nanotubes	
2	**GRAPHENE :** Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties – Band Structure of Graphene - Mobility and Density of Carriers - Quantum Hall Effect – Characterization of graphene: Raman Spectroscopy, Infrared Spectroscopy, Absorption and Photoluminescence Spectroscopy, Atomic Force Microscopy, Application of graphene	**15**
3	**CARBON NANOTUBES:** The Structure of Carbon Nanotubes- Nomenclature, Structure of Single-Walled Carbon Nanotubes and Structure of Multiwalled Carbon Nanotubes; Synthesis of CNT by various physical and chemical methods and Purification, Characterization of Carbon Nanotubes: Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes. Application of CNTs	**15**
4	**FULLERENES** : Structure and Bonding- Nomenclature, The Structure of C60, Structure of Higher Fullerenes - Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties-, Spectroscopic Properties, Thermodynamic Properties; Chemical Properties- Hydrogenation and Halogenation, Nucleophilic Addition to Fullerenes. Application of Fullerenes	**15**

TEXT BOOKS

1. **M.S. Dresselhaus, G. Dresselhaus and P.C. Eklund,** Science of Fullerenes and Carbon Nanotubes, Elsevier, 1996.
2. **Yury Gogotsi**, Carbon Nanomaterials, Taylor and Francis, 2006.
3. **Francois Leonard,** The Physics of Carbon Nanotube Devices, Elsevier, 2008.
4. **Anke Krueger**, Carbon Materials and Nanotechnology, Wiley-VCH, 2010.
5. **D.R. Askeland**, **P.P. Phule**, **W.J. Wright**, The Science and Engineering of Materials, 6th ed.,

Cengage Learning, 2010.
6. **Jamie H. Warner, Franziska Schäffel, Mark H. Rümmeli,** Graphene: Fundamentals and emergent applications, Elsevier, 2013.
7. **T. Pradeep**, NANO: The Essentials- Understanding Nanoscience and Nanotechnology, McGraw Hill Education, 2017.
8. **Deborah D L Chung**, Carbon Materials: Science and Applications, World Scientific, 2019.

Experimental Techniques in Nuclear and Particle Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Experimental Techniques in Nuclear and Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IV (2^{nd} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 406 DCEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks : 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basics of Nuclear and Particle Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to familiarize the M.Sc. students to the experimental techniques used in the fields of nuclear physics and particle physics. Various detection techniques will be introduced followed by a description of on-detector and off-detector electronics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• Get knowledge about various experimental techniques used in the fields of nuclear physics and particle physics.
• To get familiar with various detector systems and related electronics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO406D.1. Get knowledge about different types of radiations & their interaction with matter.
CO406D.2. Understand the radiation exposure and its effects on biological system.
CO406D.3. Learn about how to detect radiations.
CO406D.4. Get knowledge about the various electronic components of radiation detectors and pulse signal processing.
CO406D.5. Understand Learn about different existing detector facilities all around the world.</td></tr>
<tr><td colspan="8"></td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Radiation interactions:** Nuclear processes in radioactive sources: types of radiations & radiation sources; Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. Radiation protection, Biological effects of radiation, radiation monitoring.	15
2	**Detection of radiations:** General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Gas-filled detectors: Ionization chamber, Proportional counters, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Scintillation detector, Phoswich detectors, Cherenkov detector. Semiconductor detectors. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding.	15
3	**Detector electronics:** Electronics for pulse signal processing, CR-(RC)^n and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers, overload recovery and pileup, Linear amplifiers, single-channel analyser, analog-to-digital converters, multichannel analyzer. Basic considerations in time measurements; Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.	15
4	**Experimental Facilities:** Detector systems for heavy-ion reactions: Large neutron detector array, gamma and charge particle detector arrays, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments: basics of Collider physics, Modern Hybrid experiments- CMS and ALICE.	15

TEXT BOOKS
1. **W.R. Leo,** Techniques for Nuclear and Particle Physics Experiments, Springer, Berlin Heidelberg, 2nd Edition, 1994. 2. **Konrad Kleinknecht**, Detectors for particle radiation, Cambridge University Press, 1999. 3. **Richard Fernow**, Introduction to Experimental Particle Physics, Cambridge University Press, 2001. 4. Glenn F. Knoll**,** Radiation Detection and Measurement, John Wiley & Sons, 4th Edition, 2010.

Astronomy Laboratory

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Astronomy Laboratory</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV(2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 407 DCEC 0084</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Introduction to Astronomy and Astrophysics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course shall be providing the tools and know-how to apply the principles of astronomy first-hand.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The aim of this course to make students aware about different softwares (e.g. stellarium etc.) available to simulate night sky and observe astronomical phenomenon.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to

CO407D.1 : become familiar with astronomical coordinate system

CO407D.2 : Study the spectrum of celestial objects

CO407D.3 : observe the distance of planets

CO407D.4 : observe the proper motion of stars</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Getting to know :
Experiment 1 : To become familiar with night sky

Experiment 2: Becoming Familiar with Constellations

Experiment 3: Retrograde motion of Planets</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Spectral Analysis :
Experiment 4: Study of solar spectrum</td><td>15</td></tr>
</table>

	Experiment 5: Spectral classification of stars Experiment 6: Extracting position of a star	
3	Stellar Motions : Experiment 7: Cepheid Variables Experiment 8: To measure the Proper Motion of Barnard's Star Experiment 9: Circumpolar Star	15
4	Stellar Distances : Experiment 10: Colour Magnitude Diagram Experiment 11:Orbital Inclination Experiment 12: Planetary Distances Experiment 13: Distance to the Moon	15

References

1. http://www3.gettysburg.edu/~marschal/clea/Vireo.html
2. https://astro.unl.edu/vlabs/
3. http://va-iitk.vlabs.ac.in/
4. https://www.astro.indiana.edu/catyp/minilabs.html
5. https://depts.washington.edu/naivpl/content/welcome-virtual-planetary-laboratory

VACUUM SCIENCE AND THIN FILM TECHNOLOGY

<table>
<tr><td rowspan="2">Scheme Version:
2021-2022</td><td rowspan="2">Name of the Subject:
Vacuum Science and Thin Film Technology</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
IV
(2^{nd}Year)</td><td>Contact hours per week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 408 DCEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course:</td></tr>
<tr><td>Course Description</td><td colspan="7">The central objective of the course is to provide basic understanding of physics and technology behind thin film growth. Possible applications demonstrating novel material designs and case studies in technological areas of current interest will be discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Understand vacuum fundamentals essential to operating, maintaining, designing, or using vacuum systems.
Know the working principles and limitations of pumps, gauges, and other vacuum system components.
Learn the design concepts involved in matching equipment and instrumentation to applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO408.1 Understand the Kinetic Theory of Gases, mean free path and the physical concepts behind the thin film depositions.

CO408.2 Understand the kinetic theory of nucleation, growth and diffusion phenomenon

CO408.3 Understand the basics of vacuum science and technology, Vacuum pumps and gauges and use of various vacuum based techniques for development of thin film-based materials, structures, and plasma devices and systems.

CO408.4 Familiarize with the physical concepts of lithography behind the solid-state electronics devices design patterns.

CO408.5 Understand certain experimental techniques for characterization of thin films for their structural, morphological, surface topology, electrical, mechanical and optical</td></tr>
</table>

	properties. **CO408.6** Design protocols for thin film deposition, characterization and various applications.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**The physics of gases and vacuum systems:** Gas kinetics, Maxwell-Boltzmann distribution, molecular impingement flux, Knudsen equation, mean free path, transport properties, Evaporation: thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, deposition monitoring techniques, Deposition: adsorption, surface diffusion, nucleation, structure development, interfaces, stress, adhesion.	15
2.	**Vacuum Science and deposition techniques:** Basics of vacuum science, creation of vacuum using different pumps, vacuum gauges, vacuum leak detection, helium leak detector, residual gas analyzer. Thermal evaporation and electron beam evaporation system, idea of DC and R.F. sputtering system, Methods of producing thin films using Physical vapour deposition, Chemicals Vapour Deposition and spray pyrolysis methods, Molecular Beam Epitaxy and Laser Ablation methods for thin film deposition.	15
3.	**Lithography:** Importance of lithography, Basic steps of lithography, Substrate preparation methods, Positive photoresist, Negative photoresist, photoresist Processing, photoresist coating methods, Resist Exposure (single, bi-layer and multi-level photoresist exposure) and Resist Development, soft backing and hard baking, Etching, Types of lithography, Photolithography, Idea of electron beam lithography, Idea of an X-ray lithography, Interference Lithography, Step Growth, Nano imprint, Self-Assembly, Nano templates.	15

4.	**Thin Film Analysis and Applications:** Film analysis: structure-thickness, topography, inhomogeneity, crystallography, bonding, point defects, composition, optical, electrical and mechanical behavior of thin films. Thin film technology applications: optical windows, integrated circuits, micro-electro-optomechanical systems and photovoltaics.	15

REFERENCE BOOKS

1. Chopra, K.L., Thin Film Phenomena, Robert E. Krieger publishing, 1969.
2. Smith, D.L., Thin-Film Deposition: Principles and Practice, McGraw-Hill, 1995.
3. Hummel, R. E. and Guenther, K.H., Handbook of Optical Properties: Thin Films for Optical Coatings, Volume 1, CRC Press, 1995.
4. Ohring, M., The Materials Science of Thin Films, 2nd Edition, Academic press, 2002.
5. Soriaga, M.P., Stickney, J., Bottomley, L.A., and Kim Y.G, Thin Films: Preparation, Characterization, Applications, Springer Science 2011.

Minor Research Project

Scheme Version:	**Name of the subject:**		**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
2021-22	Minor Project		0	0		4	IV (2nd Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 409 DCEC 00016	**Applicable to Programs:** M.Sc. Physics		**Evaluation (Total Marks : 100)**	**CIE**	00	**Examination Duration:** 3 hours		
				TEE	100 Marks	**Prerequisite of Course:** None		
Course Description		The minor project topic will be decided on the basis of student skill and interest. On mentor will be allocated to student for discussion and direction.						
Course Objectives		• Student will have idea about the literature survey and how to write an overview.						
Course Outcomes		After completion of this project, students will be able to learn about: **CO409.1.** Basic of literature review **CO409.2.** Learn how to do research **CO409.3.** How to write a report. **CO409.4.** Present the work done in minor project.						

Evaluation: The evaluation will be done by a Departmental committee constituted by Head of the Department. Committee will award the grades based on quality of project work done and presentation made by student.

INTRODUCTION TO HYDROGEN ENERGY SYSTEMS

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:
Introduction to Hydrogen Energy Systems</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2nd Year)</td><td>Contact hours per week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 410
DCEC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">To introduce the concept of energy generation from Hydrogen as future fuel. To enlighten the knowledge of production, storage and transportation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">This course aim is to give insight of hydrogen production, storage and their application, as a future source of energy.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO410.1 The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues.
CO410.2 There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. By observing energy efficient measures there is tremendous scope of saving energy in industry, built environment, transport etc.
CO410.3 To teach fundamentals of hydrogen energy as energy systems, production processes, separation and utilization that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.
CO410.4 This course has objectives to elaborate PG students regarding current trends in hydrogen energy architecture and following key concepts such as hydrogen storage and hydrogen sensing.
CO410.5. To Provide adequate inputs on a variety of issues relating to safety guidelines, codes and standards in hydrogen energy systems.</td></tr>
<tr><td></td><td colspan="7">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>5.</td><td colspan="5">Hydrogen energy pathways:[Course Outcome (s): CO410.1 & CO410.2]
Hydrogen Energy Pathways- Properties of hydrogen, Global and Indian hydrogen energy scenario, need for hydrogen, current uses, environmentally sustainable hydrogen, hydrogen as part of Climate Neutral Strategy. Hydrogen for mobility applications & vehicles, Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications.</td><td colspan="2">15</td></tr>
</table>

6.	**Hydrogen production and separation: [Course Outcome (s): CO410.3]** **Hydrogen Production**-Production of hydrogen from hydrocarbons-oxidative and nonoxidative processes, coal. Hydrogen production using nuclear energy and renewables- wind, biomass, solar. **Hydrogen separation and purification**-Pressure swing adsorption, Solvent based absorption, membrane separation, cryogenic separation etc.	15
7.	**Hydrogen storage: [Course Outcome (s): CO410.4]** **Hydrogen Storage -**Types of hydrogen storage (Gaseous, Liquid, Solid hosts), Gibbs Phase Rule, Pressure-Composition-Temperature plots; Van't Hoff plots for absorption desorption enthalpies, Gravimetric capacities, Hysteresis in cycling, Joule-Thomson Effect, Non-ideal treatment of hydrogen gas Kinetics: Hydrogen absorption/desorption phenomena (chemisorption, nucleation and growth and diffusion), Kinetic models, Kissinger analysis for activation energy estimation, Hydrogen adsorption isotherms-BET, design and applications of storage systems, materials for hydrogen storage, Hydrogen storage for automobiles.	15
8.	**Hydrogen sensing and safety**: **[Course Outcome (s): CO410.4& CO410.5]** **Hydrogen sensing-**Traditional methods of hydrogen sensing using thermal conductivity measurements or Gas Chromatography, Mass Spectroscopy or laser gas analysis; Solid state sensors- their working principle and applications at industrial scale. **Hydrogen Safety-**Physiological, physical and chemical hazards, hydrogen properties associated with hazards, Hazard spotting, evaluation and safety guidelines, Hydrogen safety codes and standards. Hydrogen safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management.	15

REFERENCE BOOKS

7. F. Peter, Fuels and Fuel Technology, A.Wheatan & Co. Ltd., 1st edition, 1965.
8. JOM Bockris, Energy options: Real Economics and the Solar Hydrogen System, Halsted Press and London publisher, 1980.
9. S. Sarkar, Fuels and Combustion, Orient Longman, 2nd edition, 1990.
10. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006.
11. J. G. Speight, The chemisty & Technology of Petroleum, 4th edition, CRC Press, 2006.
12. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009.
13. J.G. Speight and B. Ozum, Petroleum Refining Process, CRC Press, 2009.
14. W. Lyons, Working Guide to Petroleum and Natural Gas Production Engineering, Elsevier Inc, 2009.
15. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons, 2010.
16. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013.
17. J. G. Speight, The Chemistry and Technology of Coal, CRC Press, 2013.

9. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

10. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasises student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimises and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;

- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, be adopted.

11. ASSESSMENT AND EVALUATION

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. KEYWORDS

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. REFERENCES

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. APPENDICES

Department of Physics, CUH
Syllabus for Ph.D. (Physics)
According to Choice Based Credit System (CBCS)
Effective from September-2022 onwards

Course Type
- Core Course (CC)
- Discipline Centric Elective Course (DCEC)

Total Credits: 14 [Three courses]
Each student has to take the core course and one of discipline centric elective courses according to the need of the researcher whether with theoretical or experimental fields.

Semester I

Course	Course Code	Course Type	Credits
Research Methodology	SBS PHY 02 101 CC 6006	CC	6
Research and Publication Ethics	SBS PHY 02 102 CC 2002	CC	2
Any one of the following courses (DCEC)*			
Computational Techniques	SBS PHY 02 101 DCEC 5016	DCEC	6
Experimental Methods	SBS PHY 02 102 DCEC 5106		
Advanced Nuclear Physics	SBS PHY 02 103 DCEC 5106		
Total Credits			14

*The courses (DCEC) will be offered by the department depending on the requirements of the research scholars/available expertise of the faculty members.

Research Methodology

<table>
<tr><td rowspan="2">Scheme Version: 2022</td><td>Name of the subject: Research Methodology</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: Ph.D. Physics</td><td>6</td><td>0</td><td>0</td><td>6</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 02 101 CC 6006</td><td>Prerequisite: None</td><td colspan="4">Total hours = 90</td></tr>
<tr><td colspan="5">Semester I</td></tr>
</table>

Course Objective: To familiarize the students with general techniques of performing analysis of data and modelling using various simulation techniques. This course will enable students to design experiments and methods to extract data.

Learning Outcomes:

- To motivate students for research in different fields of Physics, Mathematics and Statistics.
- To teach students different techniques of research modelling, data collection, designing and planning of experiments.
- To enable to analyze data and write report based on data analyzed.

UNIT I

Research Problems: Meaning, Motivation, Objectives and types of research, Significance of research, Research proposals and aspects, Criteria of good research, Research formulation and hypotheses, Selection and necessity of defining the problem, Literature review, Reviews, Treatise, Monographs, Patents.

UNIT II

Research Design: Need, Problem Definition, Variables, Research design concepts, Research design process, Research Modeling: Types of models, Model building and stages, Data collection, processing and analysis, Simulation techniques using computer software(s).

UNIT III

Design and Planning of Experiments: Aims and objectives, expected outcome, methodology to be adopted, importance of reproducibility of research work, Interpolation, Extrapolation, Types of errors (rounding, truncation, machine and random), Error analysis and least square curve fitting. Analysis of Variance components (ANOVA) for fixed effect model, Objectives and basic principles of designs of experiments. Complete randomized design (CRD), Randomized block design (RBD) and Latin square design (LSD).

UNIT IV

Data mining and Report Writing: Library resources, Internet, Scientific search engines, Introduction to Latex/Google docs, Structure and component of research paper, Presenting the research paper/thesis, Journal impact factor, Citation index, References and bibliography, Copyright, Plagiarism and ethics in research, Communication and presentation.

Suggested Readings:

1. **Y. K. Singh,** Fundamental of Research Methodology and Statistics. New Age International Publishers, New Delhi, 1st Edition, 2008.
2. **R. Pannerselvan,** Research Methodology. Prentice Hall of India, New Delhi, 2nd Edition, 2009.
3. **D. C. Montgomery,** Design and Analysis of Experiments, Wiley, New York, 8th Edition, 2013.
4. **K. Prathapan**, Research Methodology for Scientific Research, IK International, New Delhi, 1st Edition, 2014.
5. **C.R. Kothari, G. Garg,** Research Methodology: Methods and Techniques, New Age International Publishers, New Delhi, 3rd Edition, 2014.
6. **Michal Alley,** The Craft of Scientific Writing, Springer, Germany, 4th Edition, 2018.

Research and Publication Ethics

Scheme Version: 2022	Name of the subject: Research Publications and Ethics	L	T	P	C
	Applicable to Programs: Ph.D. Physics	2	0	0	2
Subject Code: SBS PHY 02 102 CC 2002	Prerequisite: None	Total hours = 30			
	Semester I				

Course Objectives:
The aim of this course is to aware the students about the basic ethics of research and publication. The contents will serve as basic tools to groom the students about plagiarism in research.

Learning Outcomes:

On completion of the course, the student should be able to:

- Understand the basic ethics of research.
- Maintain the research integrity and intellectual honesty.
- Understand the scientific misconduct and proper citations.
- Acquire knowledge of databases and software's.

Theory

RPE 01: Philosophy and Ethics (3 hrs.)

1. Introduction to philosophy: definition, concept, branches, nature and scope,
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

RPE 02: Scientific Conduct (5 hrs.)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs.)

1. Publication ethics: definition, introduction and importance

2. Best practices/standards setting initiatives and guidance: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contribution-ship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practice

RPE 04: Open Access Publishing (4 hrs.)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE 05: Publication Misconduct (4 hrs.)

A. Group Discussion (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

1. Use of plagiarism software like Turnitin, Urkund and other open source software tools

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs.)

1. Indexing databases Research Metrics
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score
2. Metrics: h index, g index, i10 index, almetrics

Suggested Readings:

1. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance, 2019, ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

2. Chaddah, P., Ethics in Competitive Research: Do not get scooped; do not get plagiarized 2018,

ISBN:978-9387480865.

3. Beall, J. Predatory publishers are corrupting open access, Nature, 489 (7415), 179-179, 2012. https://doi.org/10.1038/489179a

4. Resnik, D. B., What is ethics in research and why is it important, National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm 2011.
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A Guide to Responsible Conduct in Research: 3rd edition , National Academics Press 2009. Bird, A., Philosophy of Science, Routledge 2006.
6. MacIntyre, A., A Short History of Ethics, London 1967.

Computational Techniques

Scheme Version: 2022	Name of the subject: Computational Techniques	L	T	P	C
	Applicable to Programs: Ph.D. Physics	5	0	1	6
Subject Code: SBS PHY 02 101 DCEC 5016	Prerequisite: None	Total hours = 90			
	Semester I				

Course Objective: The aim of course is to provide knowledge about the general features of computer and various scientific languages to students, so that they are able to apply various numerical techniques, simulation models and computational techniques to solve scientific problems.

Learning Outcomes: Students will be able to

- understand the basic structure of computer
- know the scientific languages for solving the scientific problems
- understand various numerical and simulation techniques to study theoretical aspects of problems.

UNIT I

Introduction

Overview of computer organization, Operating Systems, interfacing, hardware, workstation, servers and software used in programming, scientific programming in FORTRAN and C, C++ languages, subroutines, arrays , matrices, functions and usage of library files..

UNIT II

Numerical Techniques

Sorting interpolation, extrapolation, regression, numerical integration, quadrature, random number generation, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, Euler, Runge-Kutta, and Verlet schemes, root searching, optimization, fast Fourier transform.

UNIT III

Simulation Techniques

Monte Carlo methods, molecular dynamics, simulation methods for the Ising model and atomic fluids, simulation methods for quantum-mechanical problem, time-dependent Schrödinger equation, discussion of selected problems in percolation, cellular automata, nonlinear dynamics, traffic problems, diffusion-limited aggregation, celestial mechanics, etc.

UNIT IV

Parallel Computation

Introduction to parallel computation, shared and distributed memories, automatic versus manual parallelization, partitioning, communication and synchronization of parallel program, Examples of parallel program

Suggested Readings:

1. D. W. Heermann, Computer Simulation Methods in Theoretical Physics, Springer, Germany, 2nd Edition, 1995.
2. V. Rajaraman, Computer Programming in Fortran 90, Prentice Hall of India, New Delhi, 1st Edition, 1997.
3. J.M. Thijssen, Computational Physics, Cambridge University Press, 1st Edition, 1999.
4. **D. Frenkel and B. Smit,** Understanding Molecular Simulation, Academic Press, USA, 2nd Edition, 2001.
5. H. M. Antia, Numerical Methods for Scientists and Engineers, Birkhauser, Switzerland, 2nd Edition, 2002.
6. H. Gould and J. Tobochink, An Introduction to Computer Simulation Methods, Addison-Wesley, US, 3rd Edition, 2006.
7. W. H. Press, B. P. Flannery, S. A. Teukolsky and W. T. Vetterling, Numerical Recipes in FORTRAN: The Art of Scientific Computing. (Similar volumes in C, C++). Cambridge University Press, 3rd Edition, 2007.
8. M. P. Allen, Computer Simulation of Liquids, Oxford University Press, 2nd Edition, 2017**.**
9. Kurt Binder and Heerman, Monte Carlo Simulation in Statistical Physics, Springer, Germany, 6th Edition,2019.

Experimental Methods

Scheme Version: 2022	Name of the subject: Experimental Methods	L	T	P	C
	Applicable to Programs: Ph.D. Physics	5	1	0	6
Subject Code: SBS PHY 02 102 DCEC 5016	Prerequisite: None	Total hours = 90			
	Semester I				

Course Objective: The course has been developed to teach various experimental techniques/methods for performing research in experimental physics.

Learning Outcome: Students will be able to

- understand and implement vacuum, thin film technology.
- apply photon and electron beam based techniques for surface analysis.
- know the technique for surface structure and composition analysis.

UNIT I

Vacuum Technology: Production and Measurement of Rough to Ultra High Vacuum; various vacuum ranges, applications of vacuum technology, pressure and mean free path, Design of vacuum systems; Leak detection methods, Vacuum Materials.

UNIT II

Thin Film Technology: Synthesis of thin films for research and technological applications, Electrodeposition, Chemical vapor deposition, cluster interaction deposition, choice of thin film substrates etc, Thermal evaporation and sputtering.

UNIT III

Photon and Electron beam based techniques for surface analysis: Auger Electron spectroscopy (AES): Basic Principle, methodology and Instrumentation, Applications of AES in Composition analysis and depth profiling. X-ray photoelectron spectroscopy (XPS) or ESCA: Principle, Instrumentation, Methodology, Quantitative analysis and Applications. Glancing angle X-ray diffraction, Basic concept, Instrumentation methodology and structural analysis applications.

UNIT IV

Techniques for surface structure and composition analysis:

Scanning electron Microscopy (SEM): Principle, Instrumentation, Methodology and Applications. Transmission Electron Microscopy (TEM): Principle, Instrumentation, Methodology for plain view and cross-sectional analysis, Applications in structural analysis. Atomic Force Microscopy (AFM): Basic principle, Methodology, typical applications in structural analysis. Energy Dispersive X-ray Fluorescence: Principle, Instrumentation, Methodology and Applications**.**

References

1. **K.L. Chopra**, Thin film phenomena, McGraw Hill, New York, 1st Edition, 1969.

2. **C. R. Brundee and A. D. Baker**, Electron spectroscopy: Theory, techniques and applications Academic Press London, US, 1st Edition, 1977.

3. **L. C. Feldman and J. W. Mayer**, Fundamentals of surface and thin film analysis, North Holland, 1st Edition, 1986.

4. **A. Roth**, “Vacuum Technology”, North Holland, 1st Edition, 2012.
5. **Douglas A Skoog et al**, Principles of Instrumental Analysis, Cengaga, San Francisco 6th Edition, 2014.
6. **Milton Ohring,** Materials Science of Thin Films, Academic Press, 20222.

Advanced Nuclear Physics

<table>
<tr><td rowspan="2">Scheme Version: 2020</td><td>Name of the subject: Advanced Nuclear Physics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: Ph.D. Physics</td><td>5</td><td>1</td><td>0</td><td>6</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 02 103 DCEC 5106</td><td>Prerequisite: None</td><td colspan="4">Total hours = 90</td></tr>
<tr><td colspan="5">Semester I</td></tr>
</table>

Course Objective: The course has been designed familiarize the students with three branches of nuclear physics based on energy and to make them to understand various phenomena occurring in energy domains.

Learning Outcome: Students will be able to

- understand various phenomenon like fusion, fission and cluster radioactivity occurring at low energy.
- know the various aspects of intermediate energy heavy ion collisions through multi-fragmentation, nuclear flow and nuclear stopping.
- classify the particles in different categories and will be able to understand the different symmetry groups.

UNIT I

Low Energy Nuclear Physics: Nuclear structure and properties, Nuclear spectroscopy, Nuclear shapes, Nuclear forces, Heavy ion collisions; Skyrme Energy Density Formalism, Theory of low energy Nuclear reactions; Quantum Mechanical Fragmentation Theory, Physics of radioactive ion beams, Nuclear astrophysics, Physics of nuclei near drip line and strange matter, Island of stability in super-heavy region, Cluster radioactivity and super asymmetric fission.

UNIT II

Intermediate Energy Nuclear Physics: Heavy Ion Collisions, Multifragmentation, Elliptical Flow, Transverse Flow, Experimental Scenario, Sub threshold Particle production, Time dependent Hartree Fock Theory, Vlasov Uehling Uhlenbeck and Boltzmann Uehling Uhlenbeck Theory, Statistical Models, Quantum Molecular Dynamics Model, Isospin Quantum Molecular Dynamics Model, Minimum Spanning Tree and Simulated Clusterization Algorithms, Monte Carlo Simulation Techniques.

UNIT III

High Energy Nuclear (Particle) Physics: Fundamental particles and Interactions, Conservation laws and invariance principles, Standard Model, SU(2) and SU(3) Symmetries and its breaking, Feynman Diagrams, Nucleons and pions, Quark model of Hadrons, Quantum Chromo dynamics(QCD), Leptons: Neutrinos and their Oscillations, Atmospheric and Solar neutrinos, Mass Hierarchy and neutrinos masses, Neutrino's oscillations probability calculations.

UNIT IV

High Energy Astrophysics:
Stellar evolution, Black hole spin, Propagation of cosmic rays, Accretion disks in AGN, Magnetic reconnection, Physics of GRBs, Quasar feedback, shock acceleration, neutron stars, and pulsars, gravitational wave astronomy, Properties of External Galaxies.

References:

1. **D. Vautherin and D. M. Brink**, Phys. Rev. **C 5** (1972) 626
2. **Burcham and Zoes,** Introduction to Nuclear & Particle Physics, John Wiley & Sons Inc, New Jersey, 2nd Edition, 1995.
3. **J. Aichelin** Phys. Rep. **202**, 233(1991); C. Hartnack et al., Eur. Phys. J **A 1**, 151(1998).
4. **W. Greiner** and **R. K. Gupta**, Heavy elements and related phenomena, World Scientific, Signapore, 1st Edition, 1999.
5. **D. H. Perkins**, Introduction to High Energy Physics, Cambridge University Press, 4th Edition, (2000).
6. **James Binney**, Galactic Dynamics, Princeton University Press, 2nd Edition, 2008.
7. **Stephen Rosswog**, Introduction to high energy physics, Cambridge University Press, 1st Edition, 2011.

Annexure-A

Annexure-IX

DEPARTMENT OF CHEMISTRY/ रसायन विज्ञान विभाग
SCHOOL OF BASIC SCIENCES/ मौलिक विज्ञान पीठ
CENTRAL UNIVERSITY OF HARYANA/ हरियाणा केंद्रीय विश्वविद्यालय
Mahendergarh, Haryana 123031/महेंद्रगढ़, हरियाणा 123031

Minutes of Meeting of the Board of Studies of the Department of Chemistry, School of Basic Sciences held on 06.09.2022

The meeting of the **Board of Studies of the Department of Chemistry, School of Basic Sciences**, Central University of Haryana, Mahendergarh was held in the office of the Head, Department of Chemistry, School of Basic Sciences, Central University of Haryana on **06.09.2022** at **10:00 A.M.** onwards.

The following members were present in the meeting:

1. **Prof. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Prof. Pawan Kumar Sharma** (External Subject Expert)
   Professor, Department of Chemistry
   Kurukshetra University, Kurukshetra, Haryana
3. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
4. **Dr. Prakash Kanoo** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

<table>
<tr><th>Item No.</th><th>Description</th><th>Any other information, if relevant</th></tr>
<tr><td>1.</td><td>To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023)</td><td>Annexure-1</td></tr>
<tr><td colspan="3">Action: Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme be approved w.e.f. Academic Session 2022-2023.</td></tr>
<tr><td>2.</td><td>To consider and approve the Scheme and Syllabi for second year and third year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026</td><td>Annexure-2</td></tr>
<tr><td colspan="3">Action: In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme of the Integrated B.Sc.-M.Sc. programme introduced in academic session 2021-2022 is being slightly modified for the first and second year in the larger interest of the students.
Further, the board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc.</td></tr>
</table>

<table>
<tr><td colspan="3">programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020.
It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.
Resolved that the scheme with modifications in first and second year and second year syllabus in the light with modifications suggested above be approved for the students enrolled in the session 2021-2026.</td></tr>
<tr><td>3.</td><td>To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023)</td><td>Annexure-3</td></tr>
<tr><td colspan="3">Action: Resolved that the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) be approved.</td></tr>
<tr><td>4.</td><td>To consider and approve the panel for practical examinations/ Project Dissertation for PG/Integrated B.Sc.-M.Sc. Programme in the Department of Chemistry</td><td>Annexure-4</td></tr>
<tr><td colspan="3">Action: Resolved that the panel for practical examinations/ Project Dissertation for PG/Integrated B.Sc.-M.Sc. Programme in the Department of Chemistry suggested in "Annexure-4" be approved.</td></tr>
<tr><td>5.</td><td>To consider and approve the panel of external examiners for TEE Question papers setting for PG/Integrated B.Sc.-M.Sc. Programmes in the Department of Chemistry</td><td>Annexure-5</td></tr>
<tr><td colspan="3">Action: Resolved that panel of external examiners for TEE Question papers setting for PG/Integrated B.Sc.-M.Sc. Programmes in the Department of Chemistry suggested in "Annexure-5" be approved.</td></tr>
<tr><td>6.</td><td>To consider and approve the panel of external examiners for TEE Question paper moderation for PG/Integrated B.Sc.-M.Sc. programme in the Department of Chemistry</td><td>Annexure-6</td></tr>
<tr><td colspan="3">Action: Resolved that the panel of external examiners for TEE Question paper moderation for PG/Integrated B.Sc.-M.Sc. programme in the Department of Chemistry suggested in "Annexure-6" be approved.</td></tr>
<tr><td>7.</td><td>To consider and approve the panel of external examiners for TEE question paper for Ph.D. programme in Chemistry</td><td>Annexure-7</td></tr>
<tr><td colspan="3">Action: Resolved that the panel of external examiners for TEE question paper for Ph.D. programme in Chemistry suggested in "Annexure-7" be approved.</td></tr>
<tr><td>8.</td><td>To consider and approve the panel of external experts for Department</td><td>Annexure-8</td></tr>
</table>

	Research Committee (DRC) in the Department of Chemistry	
Action: Resolved that the panel of external experts for Department Research Committee (DRC) in the Department of Chemistry suggested in "Annexure-8" be approved.		
9.	To consider and approve the minutes of meeting of Departmental Research Committee (DRC) to be held on 05-09-2022.	Annexure-9
Action: Resolved that the minutes of meeting of Departmental Research Committee (DRC) held on 05-09-2022 in "Annexure-9" be approved.		
10.	Any other item(s) with the permission of the Chair	-

The meeting ended with thanks to the Chair.

Prof. Vinod Kumar

Prof. Pawan Kumar Sharma

Prof. Harish Kumar

Prakash

Dr. Prakash Kanoo

Dean School Of Basic Sciences <deansobs@cuh.ac.in>

School Board Meeting on 12-09-2022 at 10:30 A.M. onwards

Dean School Of Basic Sciences <deansobs@cuh.ac.in> Wed, Sep 14, 2022 at 12:34 PM
To: "आचार्य पवन कुमार शर्मा Prof. Pawan K. Sharma" <talk2pawan@gmail.com>
Cc: bonnie_kahlon@yahoo.com, ckjaggi@gmail.com, sukhdeepsingh.cse@dcrustm.org, amitach1@yahoo.com, Amita Chandra <achandra@physics.du.ac.in>, HoD Maths <hodmaths@cuh.ac.in>, HOD Physics <hodphysics@cuh.ac.in>, HOD Statistics <hodstatistics@cuh.ac.in>, CS and IT <hodcomputerscience@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>, "HoD, Chemistry" <hodchemistry@cuh.ac.in>, ssunita@cuh.ac.in, "Dr. Suneel Kumar" <suneelkumar@cuh.ac.in>, "Dr. Harish Kumar" <harishkumar@cuh.ac.in>, Rajeshgupta@cuh.ac.in, "Dr. Manoj Gupta" <mkgupta@cuh.ac.in>, keshav@cuh.ac.in, Suraj Arya <surajarya@cuh.ac.in>, jitendra@cuh.ac.in, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, arunkajla@cuh.ac.in, "Dr. Rakesh Kumar" <rks@cuh.ac.in>, "Dr. Kapil Kumar" <kapilstats@cuh.ac.in>, kahlon_s@pu.ac.in, "Dr. Vinod Kumar" <vinodkumar@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Devendra Kumar" <devendrastats@cuh.ac.in>, drjitendra@cuh.ac.in

Respected Madam/Sir,
Please find herewith the revised minutes (with minor modification in resolution for agenda no 3a and 3b) of the meeting of the School Board held on 12-09-2022 for your kind consideration and approval.
With Warm Regards

(Revised) Minutes of Meeting of the School Board of School of Basic Sciences held on 12.09.2022

A meeting of the **School Board of School of Basic Sciences**, Central University of Haryana, Mahendergarh was held on **12.09.2022** at **10:30 A.M.** onwards via offline and online (https://meet.google.com/rvh-ukja-fwm) mode in the office of the Dean, School of Basic Sciences, Central University of Haryana.

The following members were present in the meeting:

1. **Dr. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Dr. Keshav Singh Rawat** (Member)
   Head, Department of Computer Science and IT
   Central University of Haryana, Mahendergarh
3. **Dr. Jitendra Kumar** (Member)
   Head, Department of Geography
   Central University of Haryana, Mahendergarh
4. **Dr. Rajesh Kumar Gupta** (Member)
   Head, Department of Mathematics
   Central University of Haryana, Mahendergarh
5. **Dr. Suneel Kumar** (Member)
   Head, Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
6. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
7. **Prof. Sunita Shrivastava** (Member)
   Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
8. **Dr. Manoj Kumar Gupta** (Member)

Department of Chemistry
Central University of Haryana, Mahendergarh

9. **Dr. Suraj Arya** (Member)
Department of CS & IT
Central University of Haryana, Mahendergarh

10. **Dr. Manish Kumar** (Member)
Department of Geography
Central University of Haryana, Mahendergarh

11. **Dr. Arun Kajla** (Member)
Department of Mathematics
Central University of Haryana, Mahendergarh

12. **Prof. Pawan Kumar Sharma** (External Subject Expert)
Professor, Department of Chemistry
Kurukshetra University, Kurukshetra, Haryana

13. **Prof. Chandra K. Jaggi** (External Subject Expert)
Professor, Department of Operational Research
Faculty of Mathematical Sciences, DU, Delhi

14. **Prof. Sukhdeep Singh** (External Subject Expert)
Professor, Department of Computer Science & Engg.
DCRUST, Murthal, Sonipat

15. **Prof. Amita Chandra** (External Subject Expert)
Professor, Department of Physics & Astrophysics Joined online
North Campus, DU, Delhi

16. **Prof. Simrit Kahlon** (External Subject Expert)
Professor, Department of Geography
Panjab University, Chandigarh

17. **Prof. Anil Kumar Yadav** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

18. **Dr. Jitendra Kumar** (Special Invitee)
Department of Mathematics
Central University of Haryana, Mahendergarh

19. **Dr. Devendra Kumar** (Special Invitee)
TIC, Department of Statistics
Central University of Haryana, Mahendergarh

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

Item No	**Description and Recommendation**	**Annexure**
1	Confirmation of the minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022.	
	The minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022 were confirmed.	**Annexure-1-SOBS**
2	To consider and approve the minutes of the meeting of the Board of	

	Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022, be approved.	**Annexure-A**
2a	To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-CH**
2b	To consider and approve the Scheme for first three years and Syllabi for second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in the BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc. programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020. **It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.** **Resolved that the Scheme for first three years (with minor modifications in first and second year) and Syllabi for the second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-II-CH**
2c	To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of	

	Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme and syllabi of the Integrated B.Sc.-M.Sc. programme have been designed. **Resolved that the Scheme and Syllabi for the first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-III-CH**
3.	To consider and approve the minutes of the meetings of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022, be approved.	**Annexure-B**
3a	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and suggested the improvement in the course title of Programming for Data Science as "Programming for Data Science using python" in the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023). **Further, the board suggested that the Department of Computer Science and Department of Statistics should sit together and should try to come up with a Collaborative model for the M.Sc. Data Science programme. In view of that the board resolved that the first semester Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, with minor changes as mentioned above be approved and recommended the same to the Academic Council for consideration and approval.**	**Annexure-I-CS**
3b	To consider and approve the Scheme and Syllabi of the Diploma in	

	Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and the board noted that the proposed one year Diploma Programme is of UG level and of 40 credits. However, the existing CUH ordinance allows the Diploma at PG level only with 52 credits(+-4). In view of that the board suggested that the Diploma in Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022, may be offered after the amendments in the university ordinance regarding guidelines of credits for the UG degree level diploma with updated syllabi.	**Annexure-II-CS**
4.	To consider and approve the minutes of the meeting of the Board of Studies of the Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022.	
	Resolved that the minutes of the meeting of Board of Studies of Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022, be approved	**Annexure-C**
4a	To consider and approve the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval after the incorporation of suggested corrections given below: **i) The name of the course "Solar Energy and Physics of Voltaic" is to be changed as "Fundamentals of Solar Energy".** **ii) In case of "Dissertation" offered to students in Semester IV, it should be explicitly mentioned that a continuous monitoring is required to be done. For that purpose, a minimum of two presentations are to be presented by students during the semester.** **iii) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of M.Sc. (Physics) 2021-23 batch.**	**Annexure-I-PH**
4b	To consider and approve the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session	

	2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Discussed in detail the Schemes and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme w.e.f. Academic Session 2022-2023 (Annexure-IIB-PH)and for 2021-26 batch (Annexure-IIA-PH). **Resolved that the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session 2022-2023) and for 2021-26 batch as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to implementation of below-mentioned changes:** **i) The number of practical lectures for DSE, mentioned in the schemes of Semester V and Semester VI should be four instead of two.** **ii) In case of "Dissertation" offered to students in Semester X, it should be explicitly mentioned that a continuous monitoring is required. For that purpose, a minimum of two presentations by each student are required during the semester.** **iii) A course related to "Soft Skills" may be added in the list of Ability Enhancement courses that can be offered by Department of Psychology, or Department of Education or Department of English Studies** **iv) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of Integrated B.Sc. M.Sc (Physics) for 2021-26 batch.**	**Annexure-IIA-PH** **Annexure-IIB-PH**
4c	To consider and approve the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to incorporation of below-mentioned changes: **i) The number of DCEC courses for the PhD (Physics) course work should be three. Therefore, it was decided unanimously to remove the course of "Nanotechnology and Ion Beam".**	**Annexure-III-PH**

5.	To consider and approve the minutes of the meeting of Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022	**Annexure-D1, D2, D3**
	Resolved that the minutes of the meeting of the Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022 be approved.	
5a	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-MT**
5b	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2022-27 (1-6 Semesters) as approved in BOS meeting of Department of Mathematics held 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	**Annexure-II-MT**
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics w.e.f Academic Session 2022-23, as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved, and recommended the same to Academic Council for consideration and approval.	
5c	Recommendation on the application dated 07-01-2022 received from Mr. Manish Kumar (Roll no. 191217), Research Scholar, on the recommendation of DRC (**Annexure–III-MT**), Department of Mathematics dated 13-01-2022 and BoS (16-03-2022, **Annexure-D1**).	**Annexure-III-MT**
	The case of Mr. Manish Kumar (Roll no. 191217), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 09-08-2019 and the topic of his research was approved on 19-11-2020 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Manish Kumar (Roll no. 191217), Research Scholar is required to complete a minimum residency period of two years after his topic approval date as per clause no 7.10 and 9f of Ordinance-II(A) 2019 for Ph.D. It is further resolved that the remaining**	

	residency period of 10 months 13 days should be completed in one go by Mr. Manish Kumar as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.	
6.	To consider and approve the minutes of the meeting of the Board of Studies (BOS) of the Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of Department of Statistics, School of Basic Sciences held on 10-05-2022 be approved.	**Annexure-E**
6a	To get approval for changing the instructions/notes in the course for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that changing the instructions/notes in the courses for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022, be approved and recommended the same to the Academic Council for consideration and approval.	**Annexure-E**
6b	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics, held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The agenda item 6b is withdrawn as the similar programme i.e. M.Sc. Data Science has been offered by the Department of Computer Science & Information Technology under the same School. **After detailed discussion, the board suggested that the Department of Statistics and Department of Computer Science & Information Technology may start some collaborative and common programmes in near future as per the availability of the faculty members and resources.**	**Annexure-I-ST**
6c	To consider and approve the Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the revised and updated Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics	**Annexure-II-ST**

	held on 10-05-2022, be approved and recommended the same to Academic Council for consideration and approval.	
7.	To consider and approve the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3).	
	Resolved that the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3) be approved.	**Annexure-F1, F2, F3**
7a	To consider and approve the syllabus of M.Sc. Geoinformatics programme in the Department of Geography.	
	Resolved that Scheme and Syllabi of M.Sc. Geoinformatics, two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Geography held on 24-08-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-Geog**
7b	To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job as recommended by Departmental Research Committee (DRC) held on 20-04-2022 and Board of Studies (BoS) meeting held on 11-05-2022 and to recommend the case for Academic Council.	
	The case of Mr. Sourabh Yadav (Roll no. 200785), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 29-11-2020 and the topic of his research was approved on 26-10-2021 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Sourabh Yadav (Roll no. 200785), Research Scholar is required to complete a minimum period of two years after his topic approval date as per clause no 9e and 9f of Ordinance-II(A) for Ph.D 2020. It is further resolved that the remaining period of 1 year 10 months 27 days should be completed in one go by Mr. Sourabh Yadav as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.**	**Annexure-II-Geog**
8.	Any other item(s) with the permission of the Chair.	
	No item was discussed	

The meeting ended with thanks to the Chair.

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

CBCS and LOCF and NEP-2020 Based

Curriculum and Syllabi
Of
<u>M.Sc. Chemistry</u>

(w.e.f. 2022)

DEPARTMENT OF CHEMISTRY
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	
Approval Date :	06-09-2022	12-09-2022	

Table of Contents

VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a world-class teaching and research reputation of the department that contributes society through its innovative, creative and scholarly approach.

Mission

To educate the students by adopting highest academic and professional standards to meet the global competency in the field of chemical sciences. To establish and maintain a high quality of support, research facilities, multidisciplinary and skill-based learning opportunities to our staff, students and researchers to orient them to world class creative and innovative minds.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasizing upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering ‘Knowledge of India’; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and

Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About Chemistry

Chemistry is the science of matter and its transformations. It addresses fundamental questions about the observable matter, ranging from its components, structure, properties and interconversions. As a system of knowledge, Chemistry not only explains the existence and behavior of matter around and within us, but also empowers us to manipulate the matter into new and improved forms for our use. From the ancient practices of rasayan vidya and alchemy, modern chemistry has grown over centuries into a formidable science that touches all aspects of human life. Humanity's progress in the last three centuries is pivoted on the contributions of chemistry, chemical industry and associated endeavors. The range of influence of chemistry in our life spans from essentials such as food (agrochemicals, preservatives), shelter (cement, metals, alloys, polymers) and health (drugs, cosmetics, soap, toothpaste), to advancements such as textiles (polymers, leather), beverages (flavoring and fermentation), crime fighting (forensics), weaponry (explosives), space travel (fuel) and cosmology (element detection). The list can go on endlessly. The most visible contribution of chemistry to civilization is achieved by the advancements in modern medicine that was fuelled by organic chemistry. This led to significant improvements in the living standards, extension of human average life span and fighting of dangerous diseases such as cancer and microbial infections.

Chemistry is placed centrally between the other two major branches of science, namely physics and biology. Therefore, it is often called the *central science*. It influences the developments in these two broad realms of science as much as it is influenced by the discoveries in them. The fundamental importance of chemistry and chemical industry in sustaining human civilization demands for a steady supply of trained and skilled manpower. Thus, it is unsurprising that it is an essential and integral department in higher education institutions.

Education in chemistry not only imparts the technical know-how about structure, reactions and properties of matter, but also empowers the learner to raise fundamental questions about various natural phenomena, address local issues and come up with sustainable solutions, identify areas of life where intervention of chemistry can bring about progress and imbibe and spread the spirit of free enquiry and scientific temper.

iii) About the Programme (Nature, Extent and Aims)

The Post-Graduate Programme in Chemistry will impart advanced knowledge of basic and applied chemical sciences to the graduates. It will prepare the students for taking up challenging assignments in academia and industry and also empower them with skill and knowledge for generating employment for their own and others. The Programme introduces the students to advanced developments in chemical sciences as well as in the field of other allied sciences, by providing them multidisciplinary and interdisciplinary courses. The design of choice-based curriculum can enrich students with analytical and problem-solving capabilities. It is designed to bring out the best of the abilities of each student, allow them to sharpen the scientific temper and be abreast with the contemporary developments in the area.

The programme includes a balanced combination of Core, Electives and Skill based Courses. The courses are designed in such a way to cover the entire spectrum of chemical sciences from fundamentals (that will bring admitted students from various backgrounds to a common level) to most recent advancements in the field (that will make them ready to take up challenging assignments in the real world).

The M.Sc. (Chemistry) Programme is of two years duration which is divided into four semesters. The teaching and learning in the Programme will involve theory (lectures), practicals, tutorial and seminar-based classes. During the whole programme about 40 %

syllabus of each course may be delivered via online mode and with a blended teaching-learning approach.

The curriculum will be taught through formal lectures with the aid of pre-made presentations, audio and video tools whenever necessary. Other teaching aids can also be used as and when required. The additional requirements like industrial visits, summer training and project work are also incorporated into the curriculum.

The Aims of the programme include

- To inculcate basic and advanced knowledge of chemical sciences among students.
- To provide higher education, disciplinary and inter/multi-disciplinary research-oriented knowledge to the students to make them lifelong learners.
- To provide a learned, skilled and creative pool of graduates who are ready to take up challenging assignments in different kinds of chemical industries, research institutions and academia.
- To mould responsible, proactive citizens who are equipped with scientific thinking and skills to address problems of their locality
- Adequate blend of theory, computation and hands-on experiments.
- Modernized lab courses – close to recent/current research.

iv) Qualification Descriptors (possible career pathways)

On successful completion of the M.Sc. Chemistry Programme, students of the department are expected to be ready to take up opportunities all around the world in areas that demand skills in chemical and allied sciences. As the chemical industry is enormously vast and diverse, numerous opportunities and challenges await the graduates. The graduates are expected to satisfactorily address the professional expectations, maintain a work-life balance and lead productive and meaningful lives. Some of the possible career paths for the postgraduate students may be:

1. Teaching and Research in academia

2. Research scientists in pharmaceutical and other chemical and material industries

3. Research scientists in other allied sciences

4. Entrepreneurship in chemical science-based ventures

5. Administrative Assignments in various government and private agencies

6.Chemist/Scientist/Technician assignments in any of the following industries: pharmaceutical, polymers, petrochemicals, materials sciences, nanotechnology, fuels, non-conventional energy, renewable resources, agrochemicals, fermentation and processing, paints and pigments, metallurgy, packaging, cosmetics, cements, natural products, forensics, explosives, and any other various allied branches of chemistry.

2. PROGRAMME OUTCOMES (POs)

The overall aims of the programme may be achieved by addressing its various components that are incorporated into the curriculum as described below. Each of these components is designed to lead to specific outcomes that are desired after the successful completion of the programme.

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.

PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a group and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following specific outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	To acquire a thorough knowledge about basic theoretical concepts and experimental aspects of chemistry.
PSO-2	To fully develop the skills for using the earned knowledge within different branches of chemistry.
PSO-3	To develop the attitude for identifying and solving problems using chemistry
PSO-4	To develop the capability to search, acquire and apply recent developments in research field of chemical sciences to problems
PSO-5	To develop an overview of the role of chemical sciences and chemical industry in sustaining civilization

PSO-6	To develop the skill to adopt the learned principles in various settings and innovate with the importance of sustainability in mind, if necessary

4. Postgraduate Attributes

On completion of the post graduate programme in chemistry, students are expected to be equipped with the skills of creative, critical and rational thinking associated with chemistry and its use for human society. The following attributes are expected from the students of M.Sc. Chemistry:

No.	P.G. Attributes
PGA-1	Disciplinary knowledge and solid foundation
PGA-2	Creative, critical and reflective Thinking
PGA-3	Attitudes and values
PGA-4	Principle and practical aspects of different instruments
PGA-5	Research skills
PGA-6	Think beyond which were never thought before
PGA-7	Information/digital literacy
PGA-8	Team work

5. STRUCTURE OF MASTER'S COURSE

The M.Sc. (Chemistry) Programme is of *two years* duration which is divided into four semesters. The programme under Choice-Based Credit System (CBCS) includes a balanced combination of *Core*, *Electives* and *Skill Courses* (**Table 1**).

As per P.G. Ordinance of Central University of Haryana, total credit requirement for completion of the programme shall be 96 (±4).

Total credit requirement of the present P.G. programme is **96**, however, 4 additional credit may be earned by the interested students from Swachh Bharat Internship (2 Credit) and six weeks industrial summer training course (2 Credit) (**Programme Structure**).

Table 1

Sr. No.	Types of Courses	Nature	Total Credit 98 (2 optional)	% (approx)
1	Core Courses (CC)	Compulsory Courses	48	49
2	Elective Courses (EC)	Discipline Specific Elective Courses	32	33
		Discipline Centric Elective Courses	4	4
		Generic Elective Courses	8	8
3	Skilled-based courses/ Self-study based courses	Discipline Centric Skill Courses	4	4
			96	96
4	Swachh Bharat Internship at Institute Level	Elective Optional for interested students	96 + 2 = 98	
5	Industrial Summer Training	Optional for interested students	98 + 2 = 100 Maximum credit =100	

NOTE: MOOC courses (SWAYAM) having similarity more than 75% with the core course may be offered to the students. For elective courses (whatever nomenclature may be used), the students may opt from the MOOC courses provided these courses are not in the list of core course (SWAYAM) keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

PROGRAMME STRUCTURE

Choice Based Credit System (CBCS) Based Course Structure of M.Sc. Chemistry Programme (2 Years) in Consonance with NEP-2020 and LOCF

YEAR 1

Semester-I

Course	Credit	Hrs.
IC-I (CC)	4	4
ICP-I (CC)	2	4
OC-I (CC)	4	4
OCP-I (CC)	2	4
PC-I (CC)	4	4
PCP-I (CC)	2	4
DCEC*	2	2
GEC§	4	4
Total Credit and Hrs.	**24**	**30**

IC-I: Inorganic Chemistry-I
ICP-I: Inorganic Chemistry Practical-I
OC-I: Organic Chemistry-I
OCP-I: Organic Chemistry Practical-I
PC-I: Physical Chemistry-I
PCP-I: Physical Chemistry Practical-I
*Can be chosen from the list of courses available
§GEC (Generic elective course) will be available for students from other Departments

Semester-II

Course	Credit	Hrs.
IC-II (CC)	4	4
ICP-II (CC)	2	4
OC-II (CC)	4	4
OCP-II (CC)	2	4
PC-II (CC)	4	4
PCP-II (CC)	2	4
DCSC*	2	2
GEC§	4	4
Total Credit and Hrs.	**24**	**30**

IC-II: Inorganic Chemistry-II
ICP-II: Inorganic Chemistry Practical-II
OC-II: Organic Chemistry-II
OCP-II: Organic Chemistry Practical-II
PC-II: Physical Chemistry-II
PCP-II: Physical Chemistry Practical-II
*Can be chosen from the list of courses available
§GEC (Generic elective course) will be available for students from other Departments

YEAR 2

Specialization will be offered at the beginning of semester-III
(Specializations: Inorganic Chemistry/Organic Chemistry/Physical Chemistry)

Semester-III

Course	Credit	Hrs.
Molecular Spectroscopy (CC)	4	4
Research Methodology and Software Applications (CC)	2	2
IC-III/OC-III/PC-III (DSEC-1)	4	4
IC-IV/OC-IV/PC-IV (DSEC -2)	4	4
DCEC*	2	2
Two Options (OPTION 1 and OPTION 2) are available. Students may choose any one in the beginning of Sem-III of second year)		
OPTION 1		
ICP-III/OCP-III/PCP-III (DSEP-I)	3	6
ICP-IV/OCP-IV/PCP-IV (DSEP-2)	3	6
Seminar	2	2
OPTION 2		
Dissertation–I (To be continued in Sem-IV)	8	14
Total Credit and Hrs.	**24**	**30**

IC-III and IV: Inorganic Chemistry-III and IV
OC-III and IV: Organic Chemistry-III and IV
PC-III and IV: Physical Chemistry-III and IV
ICP-III and IV: Inorganic Chemistry Practical-III and IV
OCP-III and IV: Organic Chemistry Practical-III and IV
PCP-III and IV: Physical Chemistry Practical-III and IV
*Can be chosen from the list of courses available

Semester-IV

Course	Credit	Hrs.
Applications of Spectroscopy (CC)	4	4
Seminar (Research paper based) (CC)	2	2
DCSC*	2	2
IC-V/OC-V/PC-1 (DSEC -3)	4	4
IC-VI/OC-VI/PC-VI (DSEC -4)	4	4
Options chosen in Sem-III shall be continued in Sem-IV		
OPTION 1		
ICP-V/OCP-V/PCP-V (DSEP-3)	3	6
ICP-VI/OCP-VI/PCP-VI (DSEP-4)	3	6
Scientific Report Writing in Emerging/Advanced Areas	2	2
OPTION 2		
Dissertation-II (Continued from Sem-III)	8	14
Total Credit and Hrs.	**24**	**30**

IC-V and VI: Inorganic Chemistry-V and VI
OC-V and VI: Organic Chemistry-V and VI
PC-V and VI: Physical Chemistry-V and VI
ICP-V and VI: Inorganic Chemistry Practical-V and VI
OCP-V and VI: Organic Chemistry Practical-V and VI
PCP-V and VI: Physical Chemistry Practical-V and VI
*Can be chosen from the list of courses available

Total Credit: **96** + 2 + 2 (Students can take an elective course on Swachh Bharat Internship Program during Semester-I to IV and Summer Training/Skill-based Course of six weeks at the end of Semester-II)
Total Marks for M.Sc. Programme = **2400**
Total Core Course Credit = **46**;Total Elective Course Credit = **52** (including 8 credit from GEC)
CC = Core Course; DCEC = Discipline Centric Elective Course; DSEC = Discipline Specific Elective Course; DSEP = Discipline Specific Elective Practical; DCSC = Discipline Centric Skill-based Course

Note:

1) A 02 Credit Summer Training (Optional) Self-study/Skill-based Course of six weeks will be available to interested students at the end of Semester-II.
2) A 02 Credit Elective Course on the basis of Swachh Bharat Internship Programme will be available to all students. The course can be allotted to the interested students in a batch-wise manner to earn max 02 credits in the duration of two years.
3) Students may choose option 2 in Sem-III on the basis of their interest in consultation with concerned faculty member(s). The students shall continue the dissertation work under the supervision of the same faculty member(s) to carry out second part of the dissertation in semester-IV.
4) **Choice Based Credit System (CBCS) based M.Sc. Chemistry programme will be awarded with a minimum of 96 credit (compulsory), although it can be a maximum of 100 credit.**

6. LEARNING OUTCOME INDEX

6.1 Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
POs ⇩						
PO1	√	√	X	X	X	X
PO2	√	√	√	√	X	√
PO3	√	√	√	√	√	√
PO4	√	√	√	√	√	√
PO5	√	√	√	√	√	√
PO6	X	√	√	√	√	√
PO7	X	√	X	√	√	√
PO8	√	√	√	√	√	√
PO9	√	X	√	√	√	√
PO10	X	√	√	√	√	√
PO11	X	√	√	√	√	√

6.2 Core Courses with PSOs

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
Core Course No. ⇩						
CH-01	√	√	√	X	√	√
CH-02	√	√	√	X	√	√
CH-03	√	√	√	X	√	√
CH-04	√	√	√	X	√	√
CH-05	√	√	√	X	√	√
CH-06	√	√	√	X	√	√
CH-07	√	√	√	X	√	√
CH-08	√	√	√	X	√	√
CH-09	√	√	√	X	√	√
CH-10	√	√	√	X	√	√
CH-11	√	√	√	X	√	√
CH-12	√	√	√	X	√	√
CH-13	√	√	√	X	√	√
CH-14	√	√	√	√	√	√
CH-15	√	√	√	√	√	√
CH-16	√	√	X	√	√	√

6.3 Elective and Other Courses with PSOs

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
Course No. ⇩						
CH-17	√	√	√	√	√	√
CH-18	√	√	√	√	√	√
CH-19	√	√	√	X	√	√
CH-20	√	√	√	X	√	√
CH-21	√	√	√	X	√	√
CH-22	√	√	√	X	√	√
CH-23	√	√	√	X	√	√
CH-24	√	√	√	X	√	√
CH-25	√	√	√	X	√	√
CH-26	√	√	√	X	√	√
CH-27	√	√	√	X	√	√
CH-28	√	√	√	X	√	√
CH-29	√	√	√	√	√	√
CH-30	√	√	√	√	√	√
CH-31	√	√	√	X	√	√
CH-32	√	√	√	X	√	√
CH-33	√	√	√	X	√	√
CH-34	√	√	√	√	√	√
CH-35	√	√	√	X	√	√
CH-36	√	√	√	X	√	√

CH-37	√	√	√	√	√	√
CH-38	√	√	√	√	√	√
CH-39	√	√	√	X	√	√
CH-40	√	√	√	X	√	√
CH-41	√	√	√	X	√	√
CH-42	√	√	√	√	√	√
CH-43	√	√	√	X	√	√
CH-44	√	√	√	X	√	X
CH-45	√	√	√	√	√	√
CH-46	√	√	√	X	√	√
CH-47	√	√	√	X	√	√
CH-48	√	√	√	√	√	√
CH-49	√	√	√	√	√	√
CH-50	√	√	√	√	√	√
CH-51	√	√	√	√	√	√
CH-52	√	√	√	X	√	√
CH-53	√	√	√	√	√	√
CH-54	√	√	√	√	√	√
CH-55A	√	√	√	√	√	√
CH-55B	√	√	√	√	√	√
CH-56	X	√	X	X	√	√
CH-57	√	√	X	X	√	√
CH-58	√	√	√	X	√	√
CH-59	√	√	√	X	√	√

CH-60	√	√	√	X	√	√
CH-61	√	√	√	X	√	√
CH-62	√	√	√	X	√	X

7. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

A. LIST OF COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

Sr. No	Course No	Course Name	Course Code	Course Type	Credit	Semester
CORE COURSES (CC)						
1	**CH-01**	Inorganic Chemistry-I	SBS CH 010101 C 4004	**CC**	**04**	**I**
2	**CH-02**	Organic Chemistry-I	SBS CH 010102 C 4004	**CC**	**04**	**I**
3	**CH-03**	Physical Chemistry-I	SBS CH 010103 C 4004	**CC**	**04**	**I**
4	**CH-04**	Inorganic Chemistry Practical-I	SBS CH 010104 C 0042	**CC**	**02**	**I**
5	**CH-05**	Organic Chemistry Practical-I	SBS CH 010105 C 0042	**CC**	**02**	**I**
6	**CH-06**	Physical Chemistry Practical-I	SBS CH 010106 C 0042	**CC**	**02**	**I**
7	**CH-07**	Inorganic Chemistry-II	SBS CH 010207 C 4004	**CC**	**04**	**II**
8	**CH-08**	Organic Chemistry-II	SBS CH 010208 C 4004	**CC**	**04**	**II**
9	**CH-09**	Physical Chemistry-II	SBS CH 010209 C 4004	**CC**	**04**	**II**
10	**CH-10**	Inorganic Chemistry Practical-II	SBS CH 010210 C 0042	**CC**	**02**	**II**
11	**CH-11**	Organic Chemistry Practical-II	SBS CH 010211 C 0042	**CC**	**02**	**II**
12	**CH-12**	Physical Chemistry Practical-II	SBS CH 010212 C 0042	**CC**	**02**	**II**
13	**CH-13**	Molecular Spectroscopy	SBS CH 010313 C 4004	**CC**	**04**	**III**
14	**CH-14**	Research Methodology and Software Applications	SBS CH 010314 C 2002	**CC**	**02**	**III**
15	**CH-15**	Applications of Spectroscopy	SBS CH 010415 C 4004	**CC**	**04**	**IV**
16	**CH-16**	Seminar (Research paper based)	SBS CH 010416 C 4004	**CC**	**02**	**IV**
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSEC)						
17	**CH-17**	Inorganic Chemistry-III	SBS CH 010301 DSE 4004	**DSEC**	**04**	**III**
18	**CH-18**	Inorganic Chemistry –IV (Advanced Inorganic Chemistry)	SBS CH 010302 DSE 4004	**DSEC**	**04**	**III**
19	**CH-19**	Inorganic Chemistry Practical-III	SBS CH 010303 DSE 0063	**DSEC**	**03**	**III**

20	**CH-20**	Inorganic Chemistry Practical-IV	SBS CH 010304 DSE 0063	**DSEC**	**03**	**III**
21	**CH-21**	Organic Chemistry-III (Heterocycles and Natural Products)	SBS CH 010305 DSE 4004	**DSEC**	**04**	**III**
22	**CH-22**	Organic Chemistry-IV (Reagents and Reactions)	SBS CH 010306 DSE 4004	**DSEC**	**04**	**III**
23	**CH-23**	Organic Chemistry Practical-III	SBS CH 010307 DSE 0063	**DSEC**	**03**	**III**
24	**CH-24**	Organic Chemistry Practical-IV	SBS CH 010308 DSE 0063	**DSEC**	**03**	**III**
25	**CH-25**	Physical Chemistry-III (Statistical Mechanics, Surface and Interface Chemistry)	SBS CH 010309 DSE 4004	**DSEC**	**04**	**III**
26	**CH-26**	Physical Chemistry-IV (Solid State Chemistry & Electro-Analytical Methods)	SBS CH 010310 DSE 4004	**DSEC**	**04**	**III**
27	**CH-27**	Physical Chemistry Practical-III	SBS CH 010311 DSE 0063	**DSEC**	**03**	**III**
28	**CH-28**	Physical Chemistry Practical-IV	SBS CH 010312 DSE 0063	**DSEC**	**03**	**III**
29	**CH-29**	Inorganic Chemistry-V	SBS CH 010413 DSE 4004	**DSEC**	**04**	**IV**
30	**CH-30**	Inorganic Chemistry-VI (Frontiers in Inorganic Chemistry)	SBS CH 010414 DSE 4004	**DSEC**	**04**	**IV**
31	**CH-31**	Inorganic Chemistry Practical-V	SBS CH 010415 DSE 0063	**DSEC**	**03**	**IV**
32	**CH-32**	Inorganic Chemistry Practical-VI	SBS CH 010416 DSE 0063	**DSEC**	**03**	**IV**
33	**CH-33**	Organic Chemistry-V (Organic Synthesis)	SBS CH 010417 SE 4004	**DSEC**	**04**	**IV**
34	**CH-34**	Organic Chemistry-VI (Medicinal Chemistry)	SBS CH 010418 DSE 4004	**DSEC**	**04**	**IV**
35	**CH-35**	Organic Chemistry Practical-III	SBS CH 010419 DSE 0063	**DSEC**	**03**	**IV**
36	**CH-36**	Organic Chemistry Practical-IV	SBS CH 010420 DSE 0063	**DSEC**	**03**	**IV**
37	**CH-37**	Physical Chemistry-V (Polymer & Surface Chemistry)	SBS CH 010421 DSE 4004	**DSEC**	**04**	**IV**
38	**CH-38**	Physical Chemistry-VI (Applied Electrochemistry)	SBS CH 010422 DSE 4004	**DSEC**	**04**	**IV**
39	**CH-39**	Physical Chemistry Practical-V	SBS CH 010423 DSE 0063	**DSEC**	**03**	**IV**

40	**CH-40**	Physical Chemistry Practical-VI	SBS CH 010424 DSE 0063	**DSEC**	**03**	**IV**
41	**CH-41**	Seminar	SBS CH 010425 DSE 2002	**DSEC**	**02**	**III**
42	**CH-42**	Scientific Report Writing in Emerging/Advanced Areas	SBS CH 010426 DSE 2002	**DSEC**	**02**	**IV**
DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC)						
43	**CH-43**	Reaction Mechanism: Structure and Reactivity	SBS CH 010101 DCE 2002	**DCEC**	**02**	**I**
44	**CH-44**	Nuclear Chemistry	SBS CH 010102 DCE 2002	**DCEC**	**02**	**I**
45	**CH-45**	Green Chemistry	SBS CH 010303 DCE 2002	**DCEC**	**02**	**III**
46	**CH-46**	Carbohydrate Chemistry and its Applications	SBS CH 010304 DCE 2002	**DCEC**	**02**	**III**
47	**CH-47**	Asymmetric Catalysis: Fundamentals to Frontiers	SBS CH 010305 DCE 2002	**DCEC**	**02**	**III**
48	**CH-48**	Supramolecular Chemistry	SBS CH 010306 DCE 2002	**DCEC**	**02**	**III**
49	**CH-49**	Introduction to Nanomaterials	SBS CH 010307 DCE 2002	**DCEC**	**02**	**III**
50	**CH-50**	Molecular Magnetism	SBS CH 010308 DCE 2002	**DCEC**	**02**	**III**
DISCIPLINE CENTRIC SKILL-BASED COURSES (DCSC)						
51	**CH-51**	Computational Chemistry	SBS CH 010201 DCS 2002	**DCSC**	**02**	**II**
52	**CH-52**	Analytical Techniques in Chemistry	SBS CH 010202 DCS 2002	**DCSC**	**02**	**II**
53	**CH-53**	Process Development of Active Pharmaceutical Ingredients	SBS CH 010403 DCS 2002	**DCSC**	**02**	**IV**
54	**CH-54**	Chemistry of Industrially Important Products	SBS CH 010404 DCS 2002	**DCSC**	**02**	**IV**
DISSERTATION						
55	**CH-55A**	Dissertation-I	SBS CH 010311 SE 001408	**DSEC**	**8**	**III**
56	**CH-55B**	Dissertation-II	SBS CH 010412 SE 001408	**DSEC**	**8**	**IV**
SWACHH BHARAT INTERNSHIP PROGRAMME (ELECTIVE)						
57	**CH-56**	Activities at Department and University Level	SBS CH 010105 DCS 2002	**DCSC**	**02**	**I-IV**
SUMMER TRAINING (OPTIONAL)						

58	**CH-57**	Summer Training (6 weeks)	SBS CH 010206 DCS 2002	**DCSC**	**02**	**At end of Sem-II**
GENERIC ELECTIVE COURSE (GEC) [FOR STUDENTS OF OTHER DEPARTMENTS]						
59	**CH-58**	Chemistry for Biologists	SBS CH 010101 GE 4004	**GEC**	**04**	**I**
60	**CH-59**	Chemistry of Materials	SBS CH 010102 GE 4004	**GEC**	**04**	**I**
61	**CH-60**	Medicinal Chemistry	SBS CH 010203 GE 4004	**GEC**	**04**	**II**
62	**CH-61**	Drug, Design and Discovery	SBS CH 010304 GE 4004	**GEC**	**04**	**III**
63	**CH-62**	Magneto Nuclear Chemistry	SBS CH 010405 GE 4004	**GEC**	**04**	**IV**

B. **GEC COURSE**

- Various available GEC courses can be selected from other Departments.

8. COURSE-LEVEL LEARNING OUTCOMES

INORGANIC CHEMISTRY COURSES

THEORY COURSES

<table>
<tr><td>Course No:
CH-01</td><td colspan="5">Course Name:
Inorganic Chemistry-I</td><td colspan="3">Course Code:
SBS CH 010101 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of coordination chemistry, geometries and bonding models of coordination compounds.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of symmetry, coordination chemistry, magnetic properties of coordination complexes, metal carbonyl/nitrosyl and metal clusters.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Knowledge of molecular symmetry and point groups
CO2: Understanding bonding models in coordination compounds
CO3: Application the theories and models of chemical bonding in coordination compounds
CO4: Understanding of skeleton electron pairs in non-transition compounds
CO5: Introduction to metal carbonyls, nitrosyls and related compounds
CO6: Scope of inorganic compounds</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**MOLECULAR SYMMETRY, POINT GROUPS AND CHARACTER TABLES** Symmetry elements and symmetry operations, symmetry groups with examples from inorganic compounds, groups of very high symmetry, molecular dissymmetry and optical activity, molecular symmetry for compounds having coordination number 2 to 9, matrix representations of symmetry operators and their products. The great orthogonality theorem and its importance, character tables and there use in spectroscopy.	15
II	**BONDING MODELS** Valence bond theory, electroneutrality principle and its limitations. Crystal field theory, splitting of *d*-orbitals in octahedral, tetragonal, square planar and tetrahedral ligand environments. Ligand field theory, molecular orbital theory. MO treatment of simple diatomic (homo & hetero) and polyatomic systems. Spectroscopic electronegativity, concept of chemical hardness (η). Walsh diagrams (triatomic systems).	15

III	**CHEMISTRY OF NON-TRANSITION ELEMENTS** Structures and acidic behaviour of boron halides, Types and nomenclature of boron hydrides (boranes), Wade's polyhedral skeleton electron pair theory (PSEPT). W. N. Lipscomb's STYX rules and semi-topological structures of boranes. Preparation, and properties of boron hydrides, carboranes, metalloboranes and metallocarboranes. Preparation, structure and properties of boron-nitrogen, phosphorous-nitrogen, phosphorus-oxygen, sulphur-nitrogen compounds, silicates, interhalogens, chlorofluorocarbons, pseudohalides and noble gas compounds.	15
IV	**METAL CARBONYLS, NITROSYLS AND CLUSTERS** Molecular orbital diagram of carbonyl, classification of metal carbonyls, bonding in metal carbonyl, valence electron count (EAN rules), preparation and properties of mononuclear and polynuclear carbonyl complexes, bond lengths and stretching frequencies, carbonylate ions, carbonyl hydride complexes, isolobal fragments, structure and important reactions of transition metal nitrosyls. Bonding, preparation and properties of dinuclear metal cluster (dirhenium complex $[Re_2Cl_8]^{2-}$ ions), trinuclear and hexanuclear metal clusters.	15

Suggested Readings:

1. G. L. Miessler, P. J. Fischer and D. A. Tarr, Inorganic Chemistry, 5th Edition. *Pearson*, 2014.
2. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and Its Applications, *Wiley-India*, 2010.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition. *Pearson Education*, 2006.
5. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
6. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
7. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2ndEdition. *Butterworth- Heinemann*, 1997.
8. J. D. Lee, Concise Inorganic Chemistry, *Chapman & Hall Ltd*., 1991.
9. F. A. Cotton, Chemical Applications of Group Theory, 3rd edition. *John Wiley & Sons*, 1990.

<table>
<tr><td colspan="2">Course No:
CH-07</td><td colspan="4">Course Name:
Inorganic Chemistry-II</td><td colspan="3">Course Code:
SBS CH 010207 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic understanding of electronic spectroscopy, magnetic properties and reaction mechanisms in coordination compounds.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide an understanding of the fundamentals of electronic spectroscopy of coordination compounds and advanced topics such as, reaction mechanism in complexes. Introductory nuclear chemistry and its theory will be discussed as well.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding of electronic properties of coordination compounds
CO2: Knowledge of term symbols and Orgel diagrams
CO3: Able to predict the allowed transitions between various molecular energy levels
CO4: Understanding of anomalous magnetic behaviour
CO5: Understanding of reaction mechanisms in coordination compounds
CO6: Understanding of metal-ligand equilibria in solution in coordination compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTRONIC SPECTROSCOPY AND MAGNETIC PROPERTIES-I** Spectroscopic ground states and the evaluation of energies of various J states of free ions, Term symbols, splitting of S, P, D and F terms under octahedral and tetrahedral electrostatic potential, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B and β parameters, charge transfer spectra of complexes (both metal to ligand and ligand to metal). Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information.	15
II	**ELECTRONIC SPECTROSCOPY AND MAGNETIC PROPERTIES-II** Brief review of different types of magnetic behaviors, spin-orbit coupling, quenching of orbital angular moments, temperature independent paramagnetism, anomalous magnetic moments. Crystal field theory and its application to explain magnetic properties of coordination compounds. Magnetic interactions in polynuclear systems, canting, spin frustration.	15
III	**REACTION MECHANISMS OF TRANSITION METAL COMPLEXES**	15

	Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reaction in square planar complexes, *trans* effect, mechanism of the substitution reactions. Redox reactions, mechanism of inner-outer sphere type reactions, cross reactions and Marcus-Hush theory.	
IV	**METAL-LIGAND EQUILIBRIA IN SOLUTION** Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors influencing stability of metal complexes dependent on size and charge, metal class, ligand preference, nature of transition metal ions, basic strength, chelate effect, ring size, steric strain, macrocyclic effect, thermodynamic and kinetic stability, determination of formation constants by pH-metry and spectrophotometry.	15

Suggested Readings:

1. G. L. Miessler, P. J. Fischer and D. A. Tarr, Inorganic Chemistry, 5th Edition. *Pearson*, 2014.
2. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and Its Applications, *Wiley-India*, 2010.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition. *Pearson Education*, 2006.
6. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
7. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
8. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2ndEdition. *Butterworth- Heinemann*, 1997.
9. J. D. Lee, Concise Inorganic Chemistry, *Chapman & Hall Ltd*., 1991.

Course No: CH-17	Course Name: Inorganic Chemistry-III						Course Code: SBS CH 010301 DSE 4004
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks:100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** To provide basic theory of various spectroscopic techniques (IR, Raman, ESR, Mossbauer, NQR) and photophysical processes involved in molecules.
Course Objectives	*To provide exposure with various spectroscopic techniques required to characterize inorganic complexes and coordination compounds. Also covered an introduction of photoinorganic chemistry involving various photophysical processes.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of IR, Raman, ESR, Mossbauer, NQR **CO2**: Basic theory of photophysical processes **CO3**: To understand spin orbit coupling **CO4**: To get insight of bond strength **CO5**: Mechanistic phenomenon **CO6**: Application of IR, Raman, ESR, Mossbauer, NQR

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INFRARED AND RAMAN SPECTROSCOPY** Molecular vibrations, force constants, molecular vibrations and absorption of Infrared radiations. Raman spectroscopy, polarized Raman lines. Use of symmetry considerations to determine the number of lines in IR and Raman Spectra. Structural studies involving IR and Raman Spectroscopy of coordination compounds containing the following molecules/ions and ligands: NH_3, H_2O, OH, SO_4^{2-}, ClO_4^-, COO^-, NO_2, CN^-, SCN^-, NO, O_2, halides, acetylacetone. Hydrogen bonding and infrared spectra, metal ligand and related vibrations. Application of resonance Raman spectroscopy to structural elucidation of the active sites of heme and non-heme oxygen carriers.	15
II	**ELECTRON SPIN RESONANCE SPECTROSCOPY** Basic principle, selection rules, presentation of spectra, origin and interpretation of Lande's factor(g), factor affecting 'g-value', isotropic and anisotropic hyperfine coupling, super hyperfine coupling, spin-orbit coupling, line shape, zero field splitting, Kramer's degeneracy, quadrupolar interactions, ESR analysis of organic compounds, transition metal complexes of vanadium, chromium, manganese, iron, copper, cobalt and iron.	15

	Application of ESR spectroscopy: structure determination, interpretation of ESR spectra of simple organic radicals like benzene, naphthalene, toluene and xylene radical ions, study of unstable paramagnetic species.	
III	**MÖSSEBAUER AND NUCLEAR QUADRUPOLE RESONANCE SPECTROSCOPY** Mössebauer Spectroscopy: Introduction to Mössebauer effect-Basic principles, recoilless emission & absorption of γ-rays. Mössebauer experiment - Instrumentation, scheme of Mössebauer spectrometer, Mössebauer spectrum. Isomer shift, quadrapole splitting and hyperfine interactions, application of Mössebauer effect to the investigations of compounds of iron and tin. Nuclear Quadrupole Resonance Spectroscopy: Principle, nuclear quadrupole resonance experiment, structural information from NQR spectra, Interpretation of nuclear quadrupole coupling constants.	15
IV	**PHOTOINORGANIC PHENOMANON** Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer's law, quantum yield, photodissociation, predissociation, photochemical reactions: photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization, photosensitized reaction. Electronic transition, Frank-Condon principle, selection rules, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, photophysical pathways of excited molecular system (radiative and non-radiative), chemiluminescence, phosphorescence and fluorescence.	15

Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5thEdition. C*engage* India, 2015.
2. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rd Edition. *New Age International (P) Ltd*., 2014.
3. N. J. Turro, V. Ramamurthy and J. C. Scaiano; Modern Molecular Photochemistry of Organic Molecules, 1stEdition. *University Science*, 2010.
4. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6thEdition. *Wiley*, 2008.
5. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rdEdition. *Springer*, New York, 2006.
6. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4thEdition. *Tata McGraw Hill*, 1994.
7. I. Ninomiya and T. Naito; Photochemical Synthesis, 1stEdition. *Academic Press*, New York, 1989.

<table>
<tr><td>Course No:
CH-18</td><td colspan="5">Course Name:
Inorganic Chemistry–IV
(Advanced Inorganic Chemistry)</td><td colspan="3">Course Code:
SBS CH 010302 DSE 4004</td></tr>
<tr><td>Batch:
2022
onwards</td><td>Programme:

M.Sc. Chemistry</td><td>Semester:

III</td><td>L

4</td><td>T

0</td><td>P

0</td><td>Credit

4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.

Pre-requisite of course: Basic knowledge of coordination chemistry, bioinorganic chemistry and supramolecular chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide exposure of (i) various biomolecules containing metal ions that comprises many important proteins and enzymes (ii) supramolecular chemistry of life. This course would be highly beneficial for students who had minimal exposure of bioinorganic chemistry at the undergraduate level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Importance of metal ions in biology
CO2: Understanding of membrane potential and its functions
CO3: Knowledge of various enzymes and its activities
CO4: Advanced applications of bioinorganic chemistry with regard to energy applications
CO5: Understanding of supramolecular chemistry of life
CO6: Knowledge of supramolecular accessories in biological systems</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**BIOINORGANIC CHEMISTRY-I** Mineral origin of life. Archaeal, Eucarial and Bacterial domain. Transition metal ions in biology. Metallobiomolecules. Electron carriers, oxygen carriers, enzymes. Specific examples: Hemoglobin, Myoglobin, Hemocyanin, Hemrythrin, Cytochromes, Fe-S proteins, Cytochrome P-450, Nitrophorin, Ferritin, blue copper proteins, di- and tricopper proteins, ceruloplasmin.	15
II	**BIOINORGANIC CHEMISTRY-II** NO-synthase, peroxidase, catalase, cytochrome-C oxidase, Other enzymes like, hydrogenase, methane monooxygenase, dioxygenases, dehydratase, nitrogenase, molybdenum containing oxidase and reductase class of enzymes like sulfite oxidase, xanthine oxidase, nitrate reductase, DMSO reductase. Zn enzymes like carbonic anhydrase, carboxypeptidase, DNA and RNA polymerases, role of manganese in water splitting.	15

III	**DEVELOPING FACETS OF MODERN INORGANIC CHEMISTRY** Oxidative generation of molecular oxygen from water during photosynthesis, Its importance from the standpoint of non-conventional energy research, Reductive cleavage of the dioxygen bond, Reductive cleavage of dioxygen bond and novel organic transformations including methane to methanol performed by a large number of Fe containing metalloenzymes.	15
IV	**SUPRAMOLECULAR CHEMISTRY OF LIFE** Biological Inspiration for Supramolecular Chemistry; Alkali Metal Cations in Biochemistry; Membrane Potentials; Membrane Transport; Rhodopsin: A Supramolecular Photonic Device; Porphyrins and Tetrapyrrole Macrocycles; Supramolecular Features of Plant Photosynthesis; The Role of Magnesium Tetrapyrrole Complexes; Neurotransmitters and Hormones; Semiochemistry in the Natural World; Structure of DNA and its Function; Site-Directed Mutagenesis; Biochemical Self-Assembly.	15

Suggested Readings:

1. J. W. Steed, Supramolecular Chemistry: From Molecules to Nanomaterials, 8 Volume Set Edition. *John Wiley & Sons*, 2012.
2. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 2nd Edition. *Wiley*, 2009.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.
6. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives. *Wiley*, 2006.
7. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
8. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry. *University Science Book, Mill Valley*, 1994.
9. I. Bertini, H.B. Gray, S. J. Lippard and J.S. Valentne, Bioinorganic Chemistry. *University Science Books, Mill Valley,* 1994.

<table>
<tr><td>Course No:
CH-29</td><td colspan="4">Course Name:
Inorganic Chemistry-V</td><td colspan="4">Course Code:
SBS CH 010413 DSE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Detailed study of bonding, structure, synthesis and reactions of various types of organometallic complexes. Metal complexes of carbons at various oxidation levels will be discussed. Synthesis and stability, precautions in handling, characterization techniques and utility or TM-complexes will be studied. The applications of metal complexes in catalysis will be studied in detail.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Fundamental understanding of organometallic compounds, reactions of various organometallics and their usefulness.</td></tr>
<tr><td>Course Outcomes :</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of organometallic compounds
CO2: Synthesis of organometallic compounds
CO3: Structural analysis of organometallic compounds
CO4: To understand fluxional behavior in organometallic compounds
CO5: To understand mechanistic study involved in organometallic compounds
CO6: Scope of organometallic compounds</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">METAL-ALKYLS, ARYLS, CARBENES AND CARBYNES
Synthesis, structure and bonding considerations of Zeise's salt; synthesis, stability and decomposition pathways of organocopper in organic synthesis; synthesis and reactivity of alkyl lithium; synthesis and reactivity of organozinc compounds.
Metal carbenes: preparation, reactivity, structure and bonding considerations of Fischer and Schrock carbene complexes, Tebbe's reagent, Grubb's reagent, Petasis reagent, Metal carbynes: synthesis, reactivity, structure and bonding considerations of Fischer and Schrock carbyne complexes.</td><td>15</td></tr>
<tr><td>II</td><td colspan="7">TRANSITION METAL PI-CYCLIC COMPLEXES
Half and bent sandwich compounds, molecular orbitals of metallocenes, structures of cyclopentadienyl compounds, covalent versus ionic bonding, 18 electron rule, synthesis, structure, aromatic behaviour of Ferrocene, reactions such as metallation, Friedel Craft, Mannich reaction, sulphonation, nitration, halogenations reactions, Synthesis, structure and reactions of other metallocenes (with Cr, Ni and Zr metals).</td><td>15</td></tr>
</table>

III	**FLUXIONAL ORGANOMETALLIC COMPOUNDS AND COUPLING REACTIONS** Rates of rearrangement and techniques of study, NMR study of Fluxional behavior, Classification of fluxional organometallic Compounds, Mechanism of fluxionality in compounds of η^1-cyclopentadienyls and η^3–allyls. Stereochemical non-rigidity in case of coordination numbers- 4 & 5 (*cis-trans*, atomic inversion, Berry Pseudorotation). Tsuji-Trost, Mizoroki-Heck, Miyaura-Suzuki, Stille, Negishi, Sonogashira, Kumada, Hiyama, Buchwald-Hartwigamination or coupling reactions.	15
IV	**CATALYTIC PROCESSES INVOLVING TRANSITION METAL ORGANOMETALLIC COMPOUNDS** Oxidative addition, reductive elimination, insertion-migration reactions, C-H bond activation catalytic mechanism of hydrogenation, hydroformylation, oxidation and isomerization of alkenes, Monsanto acetic acid synthesis, olefin metathesis, Fischer-Tropsch synthesis and Ziegler-Natta polymerization of alkenes, water gas shift reaction, asymmetric and supported organometallic catalysis.	15

Suggested Readings:

1. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rdEdition. *Pearson*, 2018.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5thEdition. *John Wiley*, 2009.
3. R. C. Mehrotra and A. Singh, Organometallic Chemistry, 2nd Edition. *New Age International*, 2007.
4. R. B. Jordan, Reaction Mechanism of Inorganic and Organometallic systems; 3rdEdition.*Oxford University Press*, 2007
5. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.

Course No: CH-30	Course Name: Inorganic Chemistry-VI (Frontiers in Inorganic Chemistry)	Course Code: SBS CH 010414 DSE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	IV	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic idea of coordination chemistry, bonding models and lanthanides.
Course Objectives	*To impart knowledge about advanced application of inorganic compounds as semiconductors, in imaging techniques, as solid adsorbents for energy applications.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Knowledge of solid state inorganic materials and bonding models **CO2:** Application of inorganic compounds as superconductors **CO3:** Application of lanthanides as chemosensors and in imaging **CO4:** Preliminary knowledge about X-ray and its use in structural determination **CO5:** Introduction hybrid materials or coordination polymers **CO6:** Use coordination polymers in catalysis and energy applications

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC MATERIALS** Brief introduction of solid state, metallic bond, Band theory (Zone model, Brillouin Zones, Limitations of the Zone model); Defects in solids, p-type and n-type; Inorganic semiconductors, its use in transistors, IC, etc.; Properties of inorganic materials: Electrical, Optical, Magnetic and Thermal. Superconductors, with special emphasis on the synthesis and structure of high temperature superconductors.	15
II	**ADVANCED APPLICATION OF LANTHANIDES** **Luminescence-based Chemosensors and Bio-imaging with Lanthanide Complexes:** Modulation of lanthanide luminescence and quenching, Chemosensor design principle, Time-resolved luminescence, Ln-based bioimaging, cellular imaging probes. **Lanthanide-base MRI Contrast Agents:** Principles of MRI, Contrast agents, Gadolinium-chelates as MRI contrast agents, water-exchange kinetics, Relaxivity, relaxation time, molecular parameters for relaxivity in MRI probes, Sensitivity and Selectivity of MRI probes, New generation MRI contrast agents.	15

III	**CRYSTAL AND MOLECULAR STRUCTURE DETERMINATION** Generation of X-rays, monochromators, safety, Concept of direct and reciprocal lattices, Bragg's law of X-ray diffraction in direct and reciprocal lattice, crystal systems, point groups, Bravais lattices, Rotational axes of symmetry, screw axes, glide planes, equivalent points, systematic absences, space groups.	15
IV	**COORDINATION POLYMERS** Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Characterization: Diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery.	15

Suggested Readings:

1. P. Martin-Ramos, M. Ramos-Silva, Lanthanide-Based Multifunctional Materials. *Elsevier*, 2018.
2. A. de Bettencourt–Dias, Luminescence of Lanthanide Ions in Coordination Compounds and Nanomaterials. *John Wiley and Sons*, 2014.
3. P. Hänninen, H. Härmä, Lanthanide Luminescence: Photophysical, Analytical and Biological Aspects. *Springer*, 2011.
4. S. R. Batten, S. M. Neville and D. R. Turner, Coordination Polymers: Design, Analysis and Application. *RSC Publishing*, 2009.
5. M.-C. Hong and L. Chen, design and Construction of Coordination Polymers. *Wiley*, 2009.
6. S. Cotton, Lanthanide and Actinide Chemistry. *John Wiley & Sons*,2006.
7. M. Ladd and R. Palmer, Structure Determination by X-ray Crystallography. *Kluwer Academic/Plenum, N.Y.*, 2003.
8. H. V. Keer, Principles of the Solid State. *Wiley Eastern Ltd.: New Delhi*, 1993.
9. A. R. West, Solid State Chemistry and its Applications. *John Wiley & Sons*, 1987.
10. J. P. Glusker and K. N. Trueblood, Crystal Structure Analysis- A Primer. *OUP, N.Y.*, 1985.
11. N. Hannay, Treatise on Solid State Chemistry. *Plenum*, 1976.
12. G. H. Stout and H. L. Jensen, X-ray Structure Determination- A Practical Guide. *Macmillan, N.Y.*, 1968.

PRACTICAL COURSES

Course No: CH-04	**Course Name:** Inorganic Chemistry Practical-I						**Course Code:** SBS CH 010104 C 0042
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** **04**
			0	0	4	2	**Total Hours:** **60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Knowledge of bonding models in coordination compounds, handling of glassware and plastic ware in laboratory.
Course Objectives	*To impart knowledge about water analysis and preparation of popular coordination complexes.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Analysis of water samples available routinely **CO2:** Determination DO, COD and BOD in water samples **CO3:** Determination of solid impurity and turbidity present in water samples **CO4:** Preparation of coordination complexes **CO5:** Appreciate the morphology and color of coordination complexes **CO6:** Basic knowledge of inorganic preparation

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	**Contents**	**Contact Hrs.**
I	**WATER ANALYSIS** 1. Determination of dissolved oxygen, DO of a given water sample. 2. Determination of chemical oxygen demand, COD of a given water sample. 3. Determination of biological oxygen demand, BOD of a given water sample. 4. Determination of total suspended solids and total dissolved solids. 5. Determination of turbidity of a water sample by nephlometer. 6. Determination of presence of Ca^{2+}, Mg^{2+}, Fe^{3+} and Fe^{2+} ions of a given water sample.	25
II	**PREPARATIONS AND RELATED COMPLEMENTARY WORK (ANY SIX)** 1. Reinecke Salt 2. $VO(acac)_2$ 3. $Mn(acac)_3$ 4. Prussian Blue/Turnbull's Blue 5. $Hg[Co(NCS)_4]$ 6. Potassium trioxalatoferate (III) Trihydrate 7. Potassium trioxaltochromate (III) 8. Cis, trans-dichlorobis(ethylenediammine)cobalt(III)chloride.	35

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5thEdition.*ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition.Longman, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry, *Van Nostrand Reinhold*, 1972.

<table>
<tr><td>Course No:
CH-10</td><td colspan="3">Course Name:
Inorganic Chemistry Practical-II</td><td colspan="4">Course Code:
SBS CH 010210 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge of quantitative estimation and radical analysis gained during undergraduate courses.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To impart knowledge of volumetric-redox and complexometric estimations and analysis of mixture of radicals, both acidic and basic.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Detailed understanding of quantitative estimations
CO2: Knowledge of volumetric-redox titrations
CO3: Knowledge of complexometric titrations
CO4: Advanced knowledge of qualitative analysis
CO5: Analysis of acidic and basic radicals from mixture of radicals
CO6: Analysis of interfering radicals present in a mixture of ions</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**QUANTITATIVE ESTIMATION** Quantitative estimation (involving volumetric-redox and complexometry) of constituents in two and three component mixtures.	30
II	**SEMIMICRO QUALITATIVE ANALYSIS** Complete systematic analysis of Inorganic mixtures containing six ions including the interfering radicals.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5th Edition. *ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5th Edition. *Longman*, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.

Course No: CH-19	**Course Name:** Inorganic Chemistry Practical-III					**Course Code:** SBS CH 010210 DSE 0063		
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** 06
			0	0	6	3	**Total Hrs.:** 90

Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks	**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Basic idea of oxidation and reduction process in inorganic complexes, vibrational and electronic spectroscopy.
Course Objectives	*To impart knowledge of experimental spectroscopic techniques and oxidation-reduction processes in coordination complexes. The students will also be introduced about single-crystals, their synthesis and characterization.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Experimental knowledge of UV-Visible and FTIR spectroscopy **CO2:** Protocol of characterizing coordination complexes by these techniques **CO3:** Experimental knowledge of oxidation-reduction reactions in coordination compounds **CO4:** Analyse and quantify inorganic samples using oxidation-reduction titrations **CO5:** Detailed understanding about single-crystals **CO6:** Synthesis and characterization of single-crystals

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**SPECTROSCOPIC STUDIES** Measurement of FTIR and UV-Visible Spectra of coordination compounds, data plotting, analysis and characterization of coordination complexes/compounds using Infrared and UV-Visible Spectroscopy.	30
II	**OXIDATION-REDUCTION TITRATIONS** (i) Preparation of 0.1M cerium (IV) sulphate and its standardization with ammonium iron(II) sulphate or sodium oxalate. (ii) To determine the concentration of the nitrite ions in the sample solution using standardized cerium (IV) sulphate. (iii) To determine the percentage purity of the $NaNO_2$ using standardized cerium (IV) sulphate.	30
III	**SINGLE-CRYSTALS** Methods of growing single-crystals: (i) Diffusion method; (ii) Hydrothermal and Solvothermal method; (iii) Slow evaporation method. To grow single-crystals of molecular compounds, metal-organic cages and metal-organic higher dimensional compounds. Identification of single-crystals under polarizing optical microscope.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5th Edition. *ELBS*, 1989.
2. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.
3. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6th Edition. *Wiley*, 2008.
4. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.

<table>
<tr><td>Course No:
CH-20</td><td colspan="3">Course Name:
Inorganic Chemistry Practical-IV</td><td colspan="4">Course Code:
SBS CH 010304 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td>Total Hrs.: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="6">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Preliminary knowledge of electrochemistry, chromatography and quantitative analysis.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To gain knowledge about various techniques for the characterization of inorganic and coordination compounds through hands-on-practice.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of chromatography
CO2: Development of experimental skills to separate ions from mixtures
CO3: Basic understanding of volumetric and gravimetric methods
CO4: Characterization of compounds
CO5: Estimation of metals from samples
CO6: Interpretation of outcomes</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHROMATOGRAPHY** Separation of binary mixtures in the given solution by paper chromatography, visualizing solution: concentrated ammonia, ascending chromatography.	30
II	**GRAVIMETRY** To prepare solutions of different metal ions and estimate the metal ions gravimetrically. Three component metal ion analysis (one volumetric and two gravimetric method).	30
III	**IODIMETRIC TITRATIONS** Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). Estimation of (i) arsenite and (ii) antimony iodimetrically Estimation of available chlorine in bleaching powder iodometrically	30

Suggested Readings:

1. J. A. I. Mendham, Vogel's Quantitative Chemical Analysis, 6thEdition. *Pearson*, 2009.
2. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5thEdition. *ELBS*, 1989.
3. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition. *Longman*, 1979.
4. Marr and Rocket, Practical Inorganic Chemistry, *Van Nostrand Reinhold*, 1972.

Course No: CH-31	Course Name: Inorganic Chemistry Practical-V						Course Code: SBS CH 010415 DSE 0063
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 06**
			0	0	6	3	**Total Hrs.: 90**

Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks	**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Basic knowledge of preparation, estimation and characterization of inorganic compounds.
Course Objectives	*To enable students analyse and characterize the given inorganic sample with knowledge of spectroscopy and titrations.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1: Determination of absorbance of an inorganic sample** **CO2: Determine the concentration of sample with the help of absorbance** **CO3: Knowledge of precipitation titrations** **CO4: Determination of chloride in neutral solution using precipitation titrations** **CO5: Knowledge of titrations** **CO6: Interpretation of electronic and magnetic properties of inorganic complexes**

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**EXPERIMENTAL DETERMINATIONS WITH ULTRAVIOLET /VISIBLESPECTROPHOTOMETERS** (i) Determination of the absorption curve and concentration of a Substance (potassium nitrate) (ii) Simultaneous spectrophotometric determination (chromium and manganese)	30
II	**PRECIPITATION TITRATIONS** (i) Preparation of 0.1M silver nitrate and its standardization with Mohr's method using potassium chromate/adsorption indicator. (ii) Determination of chloride in neutral solution by titration with standard 0.1 M silver nitrate.	30
III	**PREPARATION, CHARACTERIZATION AND ESTIMATION (ANY TWO)** (i) Preparation of hexamminecobalt(III) chloride and determine the percentage of cobalt in the product iodimetrically. (ii) Preparation of chloropentaammine cobalt (III) chloride and interpretation of electronic spectrum and magnetic properties. (iii) Preparation of $[Co(acac)_3]$ and interpretation of electronic spectrum and magnetic properties.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham,Vogel's Textbook of Quantitative Analysis, revised, 5thEdition. *ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition. *Longman*, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.
4. Pass, G.; Sutcliffe Practical Inorganic Chemistry, 1stEdition.*Chapmann and Hall Ltd.*, 1968.
5. Jolly, W.L. Synthetic Inorganic Chemistry, 2ndEdition.*Prentice Hall, Inc.*, 1961.

<table>
<tr><td>Course No:
CH-32</td><td colspan="4">Course Name:
Inorganic Chemistry Practical-VI</td><td colspan="4">Course Code:
SBS CH 010416 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td colspan="2">Total Hrs.: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="7">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic knowledge of ores, alloys and rare earth elements. Knowledge of qualitative and quantitative analysis.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To train students to analyse ores and alloys and extract/separate rare earth elements. Also impart knowledge to analyse and estimate selected inorganic compounds.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Knowledge of analysis of ores and alloys
CO2: Practical analysis of samples of ores and alloys
CO3: Analysis of selected inorganic complexes
CO4: Knowledge of purification and structural elucidation
CO5: Knowledge of rare earth samples
CO6: Extraction and separation of rare earth from the given samples</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**ANALYSIS OF ORES, ALLOYS BY QUALITATIVE AND QUANTITATIVE METHODS** Chemical methods for analysis of ores and alloys by qualitative and quantitative methods like gravimetric, radical analysis, titrimetric Ore Analysis (At least two of the following): ● Determination of Silica and Manganese in pyrolusite ● Determination of Copper and iron from chalcopyrite ● Determination of iron from hematite Alloy Analysis (At least two of the following): ● Determination of tin & lead from solder ● Determination of iron & chromium from mild steel ● Determination of copper and nickel from cupronickel	30
II	**ANALYSIS OF INORGANIC SUBSTANCES BY QUALITATIVE AND QUANTITATIVE METHODS** Preparation, purification and structural elucidation of some of the complexes from the following by available physicochemical and spectral methods: (i) $[Co(Py)_2Cl_2]$; (ii) $[Ni(NH_3)_6]Cl_2$; (iii) $Ni(dmg)_2$; (iv) $[Cu(NH_3)_4]SO_4.H_2O$; (v) Bis (cyclopentadienyl) iron (II); (vi) Ferrocene; (vii) Fe-Phenanthroline complex.	30
III	**DETERMINATION OF INDIVIDUAL CATIONS**	30

	Determination of aluminium, barium and bismuth by back titration. Determination of copper, iron(III) and nickel by direct titration.	

Suggested Readings:

1. G. Marr and B. W. Rockett, Practical Inorganic Chemistry.*Van Nostrand Reinhold*, 2019.
2. T.Dutta, K. H. Kim, M. Uchimiya, E. E. Kwon, B. H. Jeon, A. Deep and S. T. Yun, Global demand for rare earth resources and strategies for green mining. *Environ. Res.* 2016, 150, 182-190.
3. J. Derek Woolins, Inorganic Experiments. *Wiley VCH,* 2014.

ORGANIC CHEMISTRY COURSES

THEORY COURSES

Course No: CH-02	**Course Name:** Organic Chemistry-I	**Course Code:** SBS CH 010102 C 4004

Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:**	**04**
2022 onwards	M.Sc. Chemistry	**I**	4	0	0	4	**Total Hrs.:**	**60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Basic knowledge of chemical bonding, theories of bonding, stereochemistry, reaction mechanisms and reactive intermediates.
Course Objective	*To provide the basics in Organic Chemistry at the beginning of the semester. At the end of this course, students will gain the knowledge about the nature of bonding in organic molecules, delocalized chemical bonding, aromaticity, stereochemistry, such as conformation and configuration, RS and EZ notations and mechanistic aspects of aliphatic and aromatic nucleophilic substitution and electrophilic aromatic substitutions and elimination reactions.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Advanced understanding of the concepts delocalisation, conjugation and aromaticity **CO2**: Advanced knowledge of supramolecular chemistry and non-covalent bonding **CO3**: Advanced knowledge of conformational analysis, dynamic stereochemistry and asymmetric synthesis **CO4**: In-depth understanding of all classes of nucleophilic substitution reactions **CO5**: Fundamental and advanced knowledge elimination reactions and its stereochemical aspects **CO6**: Detailed mechanistic knowledge of aromatic substitution reactions

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**NATURE OF BONDING IN ORGANIC MOLECULES** Delocalized chemical bonding-conjugation, cross conjugation, resonance, rules of resonance, effect on reactivity, hyperconjugation, tautomerism; Energy level of π–molecular orbitals, Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Hückel's rule, annulenes, anti-aromaticity, homo-aromaticity; bonding in fullerenes. Fundamentals of Supramolecular Chemistry, Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.	15
II	**STEREOCHEMISTRY** ***Conformational analysis***: Simple alkanes, cycloalkanes, A values, decalins, conformational lock, ring strain, effect of conformation on reactivity.	15

	***Chirality*:** Basic principles, molecules with more than one chiral center, threo and erythroisomers, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus. Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis: basic principles, chiral pool, auxiliary, substrate, reagent and catalyst controlled.	
III	**ALIPHATIC NUCLEOPHILIC SUBSTITUTION AND ELIMINATION REACTIONS** ***a) Aliphatic Nucleophilic Substitution Reactions:*** The S_N2, S_N1, mixed S_N1 and S_N2 and SET Mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds. Classical and nonclassicalcarbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The $S_N{}^i$ mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. ***b) Elimination Reactions:*** The E2, E1 and E1cB mechanisms. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.	15
IV	**AROMATIC SUBSTITUTION REACTIONS** ***a) Aromatic Electrophilic Substitution:*** The arenium ion mechanism, orientation and reactivity. The *ortho/para* ratio, *ipso* attack, orientation in other ring systems. Friedel-Crafts reaction, Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction. ***b) Aromatic Nucleophilic Substitution:*** The $S_N{}^{Ar}$, diazonium salts and benzyne mechanisms. Reactivity–effect of substrate structure, leaving group and attacking nucleophile. The *von* Richter, Sommelet-Hauser and Smiles rearrangements.	15

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press*, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
2. R. N. Boyd, R. T. Morrison and S. K. Bhattcharjee, Organic Chemistry, 7thEdition. *Pearson*, 2014.
3. M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7thEdition. *Wiley*, 2013.
4. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
5. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, *Wiley India*, 2008.
6. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A, *Springer* 2007.
7. P. Y. Bruice, Organic Chemistry, 7thEdition. *Pearson,* 2007.
8. D. Nasipuri, Stereochemistry of Organic Compounds, Second Edition. *New Age International*, 2005.
9. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, *Longman*, 1985.

<table>
<tr><td>Course No:
CH-08</td><td colspan="4">Course Name:
Organic Chemistry-II</td><td colspan="3">Course Code:
SBS CH 010208 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge about the structure and reactions of various alkenes and carbonyl compounds; formation, stability and reactions of free radicals; fundamentals of interaction of light with matter; basic knowledge of conjugation and molecular orbital diagrams.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide advance knowledge of organic chemistry reactions such as addition reactions, free radical, photochemistry and pericyclic reactions. At the end of this course, students will be trained in solving the problems related to addition reactions, free radical reactions, photochemistry and pericyclic reactions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: In-depth understanding of electrophilic addition reaction of alkenes, alkynes and allenes
CO2: Thorough knowledge of the addition, substitution and condensation reactions of carbonyl compounds
CO3: Advanced knowledge of formation, stability and reactions of free radicals
CO4: In-depth knowledge of various photochemical reactions in organic chemistry
CO5: Ability to understand, explain and predict various aspects of pericyclic reactions such as electrocyclic reactions and cycloadditions.
CO6: Theoretical treatments and applications of sigmatropic rearrangements and chelotropic reactions</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**ADDITION REACTIONS OF CARBON-CARBON AND CARBON-HETEROATOM MULTIPLE BONDS** ***a) Polar addition to Carbon-Carbon Multiple Bonds:*** Mechanistic and stereochemical aspects of following **electrophilic addition reactions**: hydrohalogenation, hydration, epoxidation, Woodward and Prevost dihydroxylations, halogenation, halocyclizations, oxymercuration, hydrogenation, hydroboration and carbene cyclopropanation. General aspects of addition reactions of alkynes and allenes. Addition of **nucleophiles** to alkenes, Michael reaction, nucleophilic epoxidation and cyclopropanation. ***b) Addition to Carbon-Heteroatom Multiple Bonds:*** Reactivity of various carbonyl compounds, Mechanistic and stereochemical aspects of following nucleophilic addition reactions to carbonyl compounds**:** hydration, acetalization,	15

	imine and enamine formation, Grignard, organozinc and organolithium reagents, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Addition of ylides (Wittig, Julia and Peterson reactions), hydride reductions of various carbonyl compounds. Hydrolysis of acetals, esters, amides and nitriles.	
II	**FREE RADICAL REACTIONS AND ORGANIC PHOTOCHEMISTRY** ***a) Free radicals:*** Generation of free radicals, structure and stability, persistent radicals, common initiators and uses (peroxides, UV light, AIBN-tin hydride), radical anions and cations (One electron redox reactions), radical chain reactions, radical scavengers, Types of free radical reactions: substitution (halogenation, Sandmeyer reaction), addition (to unsaturated systems, radical cyclization), fragmentation (Hunsdiecker reaction), intramolecular H-abstraction (Hofmann-Loeffler and Barton reactions), oxidation (auto-oxidation of aldehydes) and dimerization (Pinacol, McMurry, acyloin and Glaser reactions) ***b) Organic Photochemistry*:** Fundamentals of organic photochemistry, Photochemical reactions of alkenes: photo-cycloaddition, Paterno-Buchi reaction, di-pi-methane rearrangement) Photochemical reactions of carbonyl compounds: Norrish type I and II reactions, di-pi methane and oxa-di-pi methane rearrangements. Basics of visible light photocatalysis.	15
III	**PERICYCLIC REACTIONS I- ELECTROCYCLIC AND CYCLOADDITION REACTIONS** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene, allyl and pentadienyl systems. Classification of pericyclic reactions. FMO approach. **Electrocyclic reactions**: conrotatory and disrotatory modes and effect on stereochemistry, 4n, 4n+2, allyl and pentadienyl systems, Nazarov cyclization. **Cycloaddition reactions:** antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, Detailed treatment of Diels-Alder reactions (types of Diels-Alder reactions, common dienes and dienophiles, endo/exo selectivity, catalysis, synthetic applications, intramolecular and hetero Diels-Alder reactions), **1,3-dipolar cycloadditions**: structure, methods of preparation andsynthetic applications of nitrones, nitrile oxides and azides.	15
IV	**PERICYCLIC REACTIONS II- SIGMATROPIC, ENE AND CHELOTROPIC REACTIONS** **Sigmatropic rearrangements**: General considerations, suprafacial and antarafacial shifts of H and alkyl groups, 1,3, 1,5, 3,3 and 2,3-sigmatropic rearrangements. Valence tautomerism (divinylcyclopropane and bullvalene), Detailed treatment of Claisen (Eschenmoser, Johnson, Ireland and aromatic variants), Cope (oxy-Cope and anionic oxy-Cope) rearrangements. Wittig, aza-Wittig and Sommelet-Hauser rearrangements, concerted syn-eliminations. **Ene reactions**: General features, carbonyl and oxy-ene reactions, intramolecular ene reactions. **Chelotropic eliminations**: Definition, examples involving nitrogen, sulfur dioxide and carbon monoxide extrusions.	15

Suggested Readings:

1. S. Kumar, V. Kumar and S. P. Singh, Pericyclic Reactions, A Mechanistic and Problem-Solving Approach, Ist Edition. *Elsevier*, 2015.
2. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press*, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
3. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition. *Wiley*, 2013.
4. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
5. Morrison, Boyd and Bhattacharjee, Organic Chemistry, 7thEdition. *Pearson*, 2010.
6. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A and PART B, *Springer* 2007.
7. S. Sankararaman, Pericyclic reactions-A Textbook, 1st Edition. *Wiley-VCH, Weinheim*, 2005.
8. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, *Harcourt (India) Pvt. Ltd*., 2001.
9. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, *Longman*, 1985.

<table>
<tr><td>Course No:
CH-14</td><td colspan="2">Course Name:
Research Methodology and Software Applications</td><td colspan="5">Course Code:
SBS CH 010314 C 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge of various methods used in research, literature review skills, finding and drafting research problems and various software used to conduct research smoothly.</td></tr>
<tr><td>Course Objective</td><td colspan="7">Guiding philosophy of knowledge creation and dissemination will be discussed in this course. Features of various approaches to research, data collection, analysis and inference will be taught. Principles of formulating research problems, designing experiments and documentation will form a major part of the course. Specific objectives and techniques of chemical sciences research will also be presented.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of various types of methodologies used during research.
CO2: Basic idea of literature review and defining problems
CO3: Basic knowledge of working hypothesis.
CO4: Basic knowledge of various software used during research
CO5: Skills for writing a research report
CO6: Basic knowledge for writing dissertation</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**METHODS AND TYPES OF RESEARCH** Research methods vs Methodology. Types of research, Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research proposals- design and components.	7
II	**LITERATURE REVIEW** Importance of literature review in defining a problem, Primary and secondary sources, reviews, treatise, monographs-patents, Defining and formulating the research problem, Selecting the Problems, Development of working hypothesis.	8

III	**SCIENTIFIC SOFTWARES IN RESEARCH DESIGN** Data Analysis using Tools like MS Excel, ChemDraw and MATLAB, google scholar, chemspider, scifinder, scopus, reaxys, research gate; using advanced search techniques, web resources, e-journals, e-books, journal access, subscribing TOC alerts, hot articles, citation index, h-index and i-index, Impact factor	7
IV	**REPORTING, DOCUMENTATION AND PRESENTATION** Scientific Document; Organization and writing of research papers, short communications, review articles, monographs, peer reviewing, ethics in publishing, predatory journals and publishers, technical and survey reports, authored book and edited books and dissertation.	8

Suggested Readings:

1. A. Fink, Conducting Research Literature Reviews: From the Internet to Paper, *Sage Publications*, 2009.
2. M. Graziano, A.M. Anthony and M. L. Raulin, Research Methods: A Process of Inquiry, *Allyn and Bacon*., 2009.
3. W. M. K. Trochim, Research Methods: the concise knowledge base, *Atomic Dog Publishing*, 2005.
4. P. D. Leedy and J. E. Ormrod, Practical Research: Planning and Design, *Prentice Hall*, 2004.
5. B. L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal, An introduction to Research Methodology, *RBSA Publishers*, 2002.
6. R. A. Day, How to Write and Publish a Scientific Paper, *Cambridge University Press*, 1992.
7. C. R. Kothari, Research Methodology: Methods and Techniques*, New Age International*, 1990.
8. S. M. Coley and C. A. Scheinberg, Proposal Writing, *Sage Publications*, 1990.

Course No:	Course Name:	Course Code:
CH-21	Organic Chemistry-III (Heterocycles and Natural Products)	SBS CH 010305 DSE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	III	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic and advanced knowledge of the chemistry of heterocycles and natural products.
Course Objective	*This paper will provide a basic and advanced knowledge of the chemistry of heterocyclic and natural products including heterocycle reactivity, synthesis and chemical reactions of small to large member heterocycles and their importance in the field of medicine, natural product isolation and its structure determination, synthesis and biosynthesis and its uses during the drug discovery and development process.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic and advance knowledge of understanding heterocylic chemistry: the synthesis, chemical transformation and reaction mechanism **CO2**: Basic and advance knowledge about different class of natural products **CO3**: Skills for analyzing and developing new sustainable methods **CO4**: Skills for developing industrially important methods **CO5**: Development of alternate and new eco-friendly synthetic pathways to chemicals **CO6**: Application and importance in drug discovery and development process.

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION AND CHEMISTRY OF SMALL RING HETEROCYCLES** Introduction, nomenclature, spectral characteristics, reactivity of heterocyclic compounds. Synthesis and reactions of three, four and five membered heterocycles (aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes, pyrrore, thiophene and furan).	15
II	**CHEMISTRY OF SIX MEMBERED AND BENZOFUSED HETEROCYCLES** Synthesis and reactions of six membered heterocycles, pyridine, pyrylium salts, pyridinium&thiopyrirylium salts. Chemistry of bicyclic compounds containing one or more heteroatom. Benzofused five and six membered rings: synthesis and reactions of indoles, benzofuran, benzothiophene, quinlolin, Isoquinoline, quinolones, isoquinolines, benzotriazoles, quinolinizium and benzopyrylium salts.	15

III	**CHEMISTRY OF NATURAL PRODUCTS: TERPENOIDS, CAROTENOIDS AND STEROIDS** ***Terpenoids and Carotenoids***: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Stereochemistry, Synthesis (chemical/biosynthesis) of the following representative molecules: Citral, α-Terpeneol, Farnesol, Santonin, Phytol and β-carotene. ***Steroids***: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation and biosynthesis of Cholesterol. Synthesis of Testorosterone, Progesterone, Oestrone.	15
IV	**CHEMISTRY OF NATURAL PRODUCTS: ALKANOIDS AND FLAFONOIDS** ***Alkaloids***: Definition, nomenclature, occurrence, isolation, general methods of structure elucidation, classification based on nitrogen heterocyclic ring. Stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Nicotine, Atropine and Quinine. ***Flavonoids***: Introduction, isolation and purification of flavonoids, General methods of structural determination of flavonoids, Biosynthesis of flavonols and related polyphenols.	15

Suggested Readings:

1. J. Clayden, B. Greeves and S. Warren, Organic Chemistry, Second Edition, *Oxford University Press*, 2012.
2. B. A. Bohm, Introduction to Flavonoids, *Harwood Academic Publishers*, 2011.
3. I. L. Finar, Organic Chemistry, Vol. 2*, ELBS*., 2009
4. Atta-ur-Rahman and Choudhary, Chemistry, *Harwood Academic Publishers*, 2008.
5. E. S. Coffey, Rodd's Chemistry of Carbon Compounds, *Elsevier*, 2005
6. J. A. Joule, Heterocyclic Chemistry, *ELBS*, 2005
7. Mann, Davidson, Hobbs, Banthrope and Harborne, Natural products: Chemistry and Biological Significance, *Longman*, Essex., 2004.
8. T. Eicher and S. Hauptmann, The Chemistry of Heterocycles, *Thieme*, 2002.
9. G. R. Newkome and W. W. Paudler, Contemporary Heterocyclic Chemistry, *Wiley-Interscience*, 1995.
10. T. L. Gilchrist, Heterocyclic Chemistry*, Longman Scientific Technical*, 1990.
11. R. M. Acheson, An Introduction to Heterocyclic Chemistry, *John Wiley*, 1980
12. A. R. Katritzky and C. W. Rees, Comprehensive Heterocyclic Chemistry, *Pergamon Press*, 1970.

Course No:	Course Name:	Course Code:
CH-22	Organic Chemistry-IV (Reagents and Reactions)	SBS CH 010306 DSE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	III	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. Pre-requisite of course: Basic knowledge of the classical reagents and reactions used commonly in organic synthesis
Course Objective	*To provide the advanced knowledge of organic synthesis in general and classical and modern reagents and methods in synthesis in particular. In-depth knowledge of metal-mediated reactions and common metal-based reagents, oxidation-reduction reactions and reagents and rearrangement reactions will be gained. At the end of the course students are expected to predict reagents and conditions needed for specific conversions.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Advanced knowledge of modern methods of manipulations of carbonyl compounds, theoretical explanations of and reactivity including stereochemistry **CO2**: In-depth understanding of the use of various transition metal-based catalysts in coupling reactions **CO3**: Modern, classical and green methods of oxidation of various functional groups **CO4**: Common reduction methods in organic synthesis **CO5**: Environmentally friendly and stereoselective modern processes in organic synthesis **CO6**: Thorough understanding of various rearrangement reactions and their applications in synthesis

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**USE OF METALS IN ORGANIC SYNTHESIS** Selective enolate generation using LDA, LHMDS, KHMDS; Modern aldol reactions (lithium, boron, and titanium enolates), Zimmerman-Traxler TS; McMurry and Tebbe olefinations; Gilman cuprates, Samarium Iodide, Palladium mediated reactions: Wacker process, Heck reaction, Stille coupling, Suzuki coupling, Negishi coupling, Sonagashira reaction and Buchwald-Hartwig amination.	15
II	**OXIDATION REACTIONS**	15

	Common oxidizing agents (transition metal oxidant, sulphur based, peroxide and peracid, modern catalytic oxidations using TEMPO) for oxidation of alcohols, ketones and aldehydes; Oxidation of C-C bonds [ozone, $KMnO_4$, $Pb(OAc)_4$, dimethyldioxirane, Ce(IV) andMn(III)] and saturated carbons, hypervalent iodine reagents, DDQ, Major methods for asymmetric epoxidations and dihydroxylations.	
III	**REDUCTION REACTIONS** Common reducing agents such as dissolving metal reductions (Birch reduction), various Aluminum and Boron derived hydrides, catalytic/transfer hydrogenations (Homogeneous and Heterogeneous), diimide, Bu_3SnH, low valent Ti species, and Wolf-Kishner reduction. Asymmetric reduction using Corey's oxazaborolidine (CBS catalyst) and Noyori's hydrogenation.	15
IV	**REARRANGEMENT REACTIONS** General mechanistic considerations, nature of migration, migratory aptitude and mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwin, Benzil-Benzilic acid, Favorskii, Arndt-Ester synthesis, Demyanov, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Dienone-Phenol, Pummerer, Smiles, Sommelet-Hauser and Achmatowicz rearrangements.	15

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd*., 2015.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, 5thEdition. *Springer Verlag*, 2012.
3. V. K. Ahluwalia, Oxidation in Organic Synthesis, *CRC press*, 2012.
4. J. H. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, 1stEdition. *University Science Books*, 2009.
5. L. Kurti and B. Czako, Strategic Applications of Name Reactions in Organic Synthesis, *Elsevier Academic Press*, 2005.
6. R. H. Crabtree, The Organometallic chemistry of the transition metals, *John Wiley*, 2005.
7. W. Carruthers and Iain Coldham, Modern Methods of Organic Chemistry, 4thEdition. *Cambridge University Press,* 2004.
8. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2ndEdition. *Oxford University Press*, 2001.
9. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7thEdition. *Wiley*, 2013.
10. S. Warren, Organic Synthesis, *Wiley*, 1982.
11. H. O. House, W. A. Benjamin, Modern Organic Synthesis, Inc., New York, 1965.

<table>
<tr><td>Course No:
CH-15</td><td colspan="5">Course Name:
Applications of Spectroscopy</td><td colspan="3">Course Code:
SBS CH 010415 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: An advanced knowledge of common and important reactions and reagents used in functional group transformations in organic synthesis. An ability to analyse complex chemical structures and find out key structural features.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide the advance knowledge and understanding of organic spectroscopy. At the end of this course, students will acquire both the theoretical and application aspect of various spectroscopic techniques (UV-Visible, IR, NMR spectroscopy and mass spectrometry) to the solve problems related to structure determination of organic compounds.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: An uptodate knowledge of modern reagents used in synthesis for FGIs and macrocycle formation
CO2: Understanding of modern trends in synthesis such as multicomponent reactions, click chemistry, CH activation and organocatalysis
CO3: Development of ability to consider and analyze the sustainability, economics, safety and toxicity aspects of organic synthesis
CO4: Ability to analyse complex molecular structures to identify key structural features and devise ways of constructing them
CO5: Understanding of strategies and tactics of organic synthesis such as protection, deprotection, umpolung, order of events etc.
CO6: Ability to read and independently understand modern synthetic endeavours and appreciate various aspects such as efficiency and aesthetics of design. Ability to design synthetic routes</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">ULTRAVIOLET AND VISIBLE SPECTROSCOPY AND MASS SPECTROMETRY
UV-Visible spectroscopy: Various electronic transitions, Beer-Lambert law, visible spectrum &colour, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugatedpolyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.</td><td>15</td></tr>
</table>

	Mass spectrometry: Introduction, ion production–EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry (HRMS).	
II	**INFRARED SPECTROSCOPY** Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance	15
III	**NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY** General introduction and definition, theory of NMR, chemical shift, shielding and deshielding mechanism, magnetic anisotropy, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), spin-spin interaction, Spin systems, Pople notation, complex spin-spin interaction between two, three and four nuclei (first order spectra), virtual coupling. chemical exchange, effect of deuteration, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents. Fourier transform technique, nuclear Overhauser effect (nOe), COSY.	15
iV	**CARBON-13 NMR SPECTROSCOPY AND COMBINED APPLICATIONS** ***Carbon-13 NMR Spectroscopy*****:** General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroarmatic and carbonyl carbon), coupling constants and DEPT ^{13}C NMR spectra. General introduction to two-dimensional NMR spectroscopy- HETCOR and NOESY. Resonance of other nuclei-F, P. ***Combined problems*****:** Combined problems relating to structure elucidation by UV, IR, NMR Spectroscopy and Mass Spectrometry.	15

Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
2. R. Kakkar, Atomic and Molecule Spectroscopy: Basic Concepts and Applications, *Cambridge University Press,* 2015.
3. W. Kemp, Organic Spectroscopy, 3rdEdition. *Mac publishers*, 2011.
4. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, *Tata McGraw-Hill*, 2010.
5. J. R. Dyer, Application of Spectroscopy of Organic Compounds, *Prentice Hall*, 2009.
6. R. J. Abraham, J. Fisher and P. Loftus, Introduction to NMR Spectroscopy, *Wiley*, 2005.
7. J. Mohan, Organic Spectroscopy, *Narosa Publishers*, New Delhi, 2002.
8. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, *John Wiley*, 1995.
9. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4thEdition, *Tata McGraw Hill*, 1994.

Course No: CH-33	**Course Name:** Organic Chemistry-V (Organic Synthesis)						**Course Code:** SBS CH 010417 DSE 4004
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** **04**
			4	0	0	4	**Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: An advanced knowledge of common and important reactions and reagents used in functional group transformations in organic synthesis. An ability to analyse complex chemical structures and find out key structural features.						
Course Objective	*To gain an in-depth understanding of various functional group transformations, classical and modern techniques in synthetic chemistry, synthetic planning and targeted synthesis of complex molecules. Detailed information and analysis of common synthetic techniques and methods will be gained. Using this knowledge, exercises on the planning of synthesis of complex scaffolds and targets will be carried out. Breakdown of complex molecules into simple building blocks for synthesis will be learned. A few case studies of total synthesis to understand the actual application of synthetic methods in real life problem solving will also be learned. Students are expected to design retrosynthesis and forward synthesis of complex targets at the end of the course.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An uptodate knowledge of modern reagents used in synthesis for FGIs and macrocycle formation **CO2**: Understanding of modern trends in synthesis such as multicomponent reactions, click chemistry, CH activation and organocatalysis **CO3**: Development of ability to consider and analyze the sustainability, economics, safety and toxicity aspects of organic synthesis **CO4**: Ability to analyse complex molecular structures to identify key structural features and devise ways of constructing them **CO5**: Understanding of strategies and tactics of organic synthesis such as protection, deprotection, umpolung, order of events etc. **CO6**: Ability to read and independently understand modern synthetic endeavours and appreciate various aspects such as efficiency and aesthetics of design. Ability to design synthetic routes						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**FUNCTIONAL GROUP TRANSFORMATIONS USING MISCELLANEOUS REAGENTS AND REACTIONS**	15

	Amide coupling reagents (DCC, DIC, EDC, BOP, HOBt), macrolactonization, Mukiyama reagent; Mitsunobu reaction; Silyl and stannyl hydrides, Burgess reagent, Lawesson's reagent, CH_2N_2, $TMSCHN_2$, Finkelstein reaction, Eschenmoser-Tanabe, Ohira-Bestmann reagent.	
II	**CLASSICAL AND MODERN METHODS IN SYNTHESIS** Illustration of the following concepts with examples; Multicomponent reactions (Strecker, Mannich, Biginelli, Passerini and Ugi reactions), click chemistry, cascade and domino processes for multiple C-C bond forming reactions (radical cyclisations, electrocyclic cascades, polyenecyclizations), CH-activation and remote functionalisation, asymmetric organocatalysis (proline, NHCs), biocatalysis, Reusable reagents, biomimetic synthesis	15
III	**RETROSYNTHESIS AND DISCONNECTION APPROACH** Concept of retrosynthesis, disconnection approach, introduction to synthons and synthetic equivalents, linear and convergent synthesis, types of transforms, functional group inter-conversions, classification of disconnections, chemoselectivity, control of stereochemistry, reversal of polarity (umploung), common building blocks, the importance of the order of events in organic synthesis, applications of alkynes, aliphatic nitro compounds, bifunctional compounds, Protecting groups, representative examples for O, N, COOH and carbonyl protection/deprotections.	15
iV	**CASE STUDIES-TOTAL SYNTHESIS** Total synthesis, Semi synthesis, formal synthesis, overall yield, concept of ideal synthesis, Detailed case study of the following classical/modern total syntheses: Periplanone B (W. C. Still), Estrone (K. P. C. Vollhardt), Quinine (G. Stork).	15

Suggested Readings:

1. S. Caron, Practical Synthetic Organic Chemistry: reactions, Principles and Technique, 2nd Edition. *Wiley*, 2020.
2. S. Warren, Designing Organic Synthesis, *Wiley*, 2011.
3. F. A. Carey and R. J. Sandburg, Advanced Organic Chemistry Part B, *Plenum Press*, 2009.
4. T. Hudlický and J. W. Reed, The Way of Synthesis, *Wiley VCH-Weinheim* 2007.
5. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis- An Introduction, *W. H. Freeman & Co*., 2007.
6. J. March, Advanced Organic Chemistry, Reactions Mechanisms and Structure, *John Wiley*, 2005.
7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, *Blackie Academic & Professional*, 2002.
8. K. C. Nicolaou and E. J. Sorensen, Classics in Total Synthesis, *Wiley VCH-Weinheim*, 1996.
9. W. Carruthers, Some Modern Methods of Organic Synthesis, *Foundation Books*, 1995.
10. Fieser and Fieser, Reagents in Organic Synthesis, *Wiley*, 1993.
11. H. O. House, W.A. Benjamin, Modern Synthetic Reactions, 1990.

Course No:	Course Name:						Course Code:
CH-34	Organic Chemistry-VI (Medicinal Chemistry)						SBS CH 010418 DSE 4004
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2022 onwards	M.Sc. Chemistry	IV	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Basic understanding of non-covalent interactions, biomolecules and biochemical processes
Course Objective	*This course will provide a basic understanding and fundamentals of Medicinal Chemistry. At the end of this course, students will learn about the various stages involved in drug discovery & development process and challenges encounter during the course of development of new drug which finally comes into the market, various biological drug targets, drug-target binding, mode of actions of anticancer, antibiotics, psychoactive drugs and its chemical synthesis.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An appreciation of the history of medicinal chemistry, understanding of basic biochemical functioning of living organisms, structural and functional details of bio-macromolecules such as proteins, nucleic acids and lipids **CO2**: Advanced knowledge about structure and functions of enzymes, receptors, DNA and RNA **CO3**: Methods of inhibition of enzymes, importance of enzyme inhibition in drug development, receptors as drug targets, signal transduction, receptor theory and DNA active drugs **CO4**: Basic concepts such as hit, lead and structure activity relationships in drug developments; theories of drug activity; importance of physical properties of drugs **CO5**: Strategies and tactics of development of various anticancer agents. Examples with synthesis. **CO6**: Approaches for the development of antibiotics, their classification, synthesis, development of drugs acting on CNS

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**DRUG TARGETS** Introduction to medicinal chemistry, intermolecular binding forces, Introduction to various drug targets; Proteins- primary, secondary and tertiary structure, protein function, proteomics; Enzymes- catalytic role, active site, allosteric binding, feedback control, binding interactions, isozymes, co-factors; Receptors- types of receptors, their roles, neurotransmitters, hormones, receptor activation and regulation; Nucleic acids- DNA, primary and secondary structure of DNA, function of DNA.	15
II	**DRUG-TARGET BINDING** Introduction to Pharmacodynamics and pharmacokinetics, Enzymes as drug targets- types of enzyme inhibitors, medicinal use of enzyme inhibitors with examples; Receptors as drug	15

	targets- agonists, antagonists, allosteric modulators, partial agonists, inverse agonists, desensitization, tolerance and dependence, affinity and efficacy; Nucleic acids as drug targets-Intercalating agents, topoisomerase poisons, alkylating/metallating agents, chain cutters, chain terminators, examples of medicinal use. Miscellaneous drug targets (tubulin)	
III	**DRUG DESIGN AND DEVELOPMENT** Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism, bioisosterism. Theories of drug activity, Quantitative structure activity relationship, Concepts of drugs receptor, Elementary treatment of drug receptor interactions, Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric factors.	15
IV	**MODE OF ACTION AND SYNTHESIS** Anticancer Agents: Introductory Idea of antineoplastic agents, cancer chemotherapy, common targets in cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Antiinfective Drugs (antibiotics): Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxicillin, Introductory idea of tetracycline and streptomycin. Psychoactive Drugs: Introductory idea of CNS depressants, general anaesthetics, hypnotics, sedatives, anti-anxiety drugs. Anti-fertility Drugs: Introductory idea of anti-fertility drugs and mode of action.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Edition. *Academic Press*, 2014.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
3. D. Van Vranken and G. Weiss, Introduction to Bioorganic Chemistry and Chemical Biology, *Garland Science*, 2013.
4. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd Edition. Pearson, 2012.
5. Ed Robert F Dorge, Wilson and *Gisvold's TextBook* of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition. 2010.
6. Ed. M E Wolff, Burger's Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Edition. *John Wiley,* 2010
7. G. Thomas, Medicinal Chemistry, 2nd Edition, *John Wiley & Sons*, 2007.
8. S. Warren, N. Greeves, J. Clayden and P. Wothers, Organic Chemistry, 2nd Edition. *Oxford University Press*, 2001.
9. S. S. Pandeya and J. R. Dimmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

PRACTICAL COURSES

Course No: CH-05	Course Name: Organic Chemistry Practical-I							Course Code: SBS CH 010105 C 0042
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L**	**T**	**P**	**Credit**		**Contact Hrs. per Week: 04**
			0	0	4	2		**Total Hours: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic idea of chemical laboratory safety and good practices; basic skills such as weighing, measuring, titrating, cleaning etc.
Course Objective	*To acquire experimental skills important for various separation and purification techniques, functional group identification and drying of organic solvents. At the end of this course, students will learn the various purification methods, chromatographic separation and identification of organic compounds, solvent drying and functional group detection in organic compounds. Students would be familiarized with quantitative analysis of organic compounds to estimate the percentage of given functional groups.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Safe laboratory conduct and good practices **CO2:** Purification techniques for solids such as crystallisation, sublimation and chromatography **CO3:** Purification techniques for liquids such as distillation and chromatography **CO4:** Qualitative analysis of unknown samples to determine the functional groups **CO5:** Tests to determine the various elements present in an organic compound **CO6:** Quantitative analysis of compounds to estimate the percentage of functional groups

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**ISOLATION AND PURIFICATION TECHNIQUES** Laboratory Safety Crystallization, recrystallization and sublimation Distillation: Simple, Steam and Vacuum Solvent Extraction Drying of ethanol/ acetone/ diethylether/THF Paper Chromatography Thin Layer Chromatography	30
II	**ANALYSIS OF ORGANIC COMPOUNDS** QUALITATIVE ANALYSIS: Chemical Tests: Chemistry and Applications Extra elements detection (N, S, X = Cl, Br, I) Functional group detection (in mono functional compounds) QUANTITATIVE ANALYSIS:	30

	Estimation of alcoholic/phenolic/amino groups in the given organic compound	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage Learning*, 2017.
2. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
3. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
4. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
5. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold, London*, 1975.
6. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold, London*, 1959.

<table>
<tr><td>Course No:
CH-11</td><td colspan="2">Course Name:
Organic Chemistry Practical-II</td><td colspan="5">Course Code:
SBS CH 010211 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Skills to handle solvent extractions, distillations, crystallisations simple chromatographic experiments independently. Ability to set up reaction assemblies which may require heating/cooling, set-up and execute filtration and drying processes.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To acquire the skills to plan and carry out separation of mixtures of organic compounds by means of solvent-solvent extraction, further purification and identification of isolated components and derivative preparation. To learn how to plan a synthetic operation from simple starting materials, set-up the reaction assembly, work-up, isolate and purify the product. Develop knowledge of proper and safe waste disposal in these operations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To analyse and separate binary mixtures of solids using solvent extraction, to purify and identify the isolated components via derivative preparation
CO2: To analyse and separate binary mixtures of solid and liquid using solvent extraction, to purify and identify the isolated components via derivative preparation
CO3: To analyse and separate binary mixtures of liquids using solvent extraction, to purify and identify the isolated components via derivative preparation
CO4: To plan and carry out single-step preparation of organic compounds
CO5: To work-up, isolate and purify, determine the purity of the prepared compound and safe treatment and disposal of chemical waste
CO6: To develop an exposure to industrial chemical operations via a visit</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**QUALITATIVE ANALYSIS OF BINARY ORGANIC MIXTURES BY A SYSTEMATIC APPROACH** Chemical separation using H_2O, $NaHCO_3$, NaOH, HCl, Ether or any other reagent as per required conditions of solid-solid, solid-liquid and liquid-liquid mixtures Systematic identification of the components and preparation of at least one derivative of each.	30
II	**A. ORGANIC SYNTHESIS** Preparation of organic compound involving one-step reaction. (Prepare at least three compounds) [**Important *Note:*** *Greener protocols to be used wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and melting points.*] **B. INDUSTRIAL VISIT**	30

	In order to get an exposure on how chemical industries function, department will arrange an industrial visit. Students to prepare a report on the industrial visit.	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition *CRC Press*, 2015.
3. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
4. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5th Edition Paperback, *Pearson*, 2003.
5. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall, Instructor's Edition,* 1992.
6. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold, London*, 1975.
7. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold, London*, 1959.

<table>
<tr><td colspan="2">Course No:
CH-23</td><td colspan="4">Course Name:
Organic Chemistry Practical-III</td><td colspan="4">Course Code:
SBS CH 010307 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2" colspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td rowspan="2" colspan="3">Total Evaluation Marks:75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="7">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Good skills for handling solvent extraction for isolation of samples, safe distillation of solvents and ability to purify samples by recrystallization from suitable solvents. Knowledge of various common reagents and the skill for their safe handling. Knowledge and concern about environmental impact of each operation.</td></tr>
<tr><td>Course Objective</td><td colspan="9">To gain the knowledge and skill for isolating and purifying important components from natural sources. To learn the methods to isolate and purify alkaloids, terpenoids, carotenoids and proteins from plant and animal sources. To learn the methods for synthesizing a target compound in a two-step procedure and isolating the purified product.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: General aspects of extraction of natural products from plant and animal sources
CO2: Specific methods for the extraction and purification of alkaloids/phenols of plant origin
CO3: Specific methods for the extraction of terpenoids, carotenoids and milk protein from the natural sources
CO4: Planning of a two-step synthesis of a given target
CO5: Execution of the planned synthesis by minimizing waste and environmental impact
CO6: Isolation, purification and conformation of the structure of all the synthesized compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**EXTRACTION OF NATURAL PRODUCTS (Alkaloids and natural phenols)** ● Caffeine from tea leaves ● Nicotine from tobacco ● Piperine from black pepper ● Curcumin from turmeric	**30**
II	**EXTRACTION OF NATURAL PRODUCTS (Terpenoids, Carotenoids and Protein)** ● Limonene from citrus rind ● Lycopene from tomatoes ● β-Carotene from carrot ● Casein from milk	**30**
III	**ORGANIC SYNTHESIS INVOLVING TWO-STEP PROCEDURE** Preparation of organic compound involving two-step reaction. (Prepare at least three compounds)	**30**

	[**Important *Note:*** *To use greener protocols wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and melting points.*]	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, *CRC Press*, 1stEdition, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. *CRC Press*, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold,* London, 1975.
11. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold*, London, 1959.

<table>
<tr><td>Course No:
CH-24</td><td colspan="5">Course Name:
Organic Chemistry Practical-IV</td><td colspan="3">Course Code:
SBS CH 010308 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td colspan="2">Total Hours: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="7">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: General and basic skill set for setting up and carrying out quantitative estimations. Knowledge of the working principle of UV-visible spectrophotometer. General synthetic skills acquired in previous semesters.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To acquire hands-on experience in organic synthesis particularly involving multistep reactions and to gain knowledge about quantitative analysis of organic compounds by spectroscopic methods. At the end of this course, students will understand and acquire the knowledge of various important parameters used in multistep organic synthesis preferably in greener approaches. Further, they would be able to characterize the synthesized compounds on the basis of their spectral data. Students would also learn the spectrophotometric methods used for quantitative analysis of organic compounds.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: General principles and skill of quantitative analysis using spectroscopic methods
CO2: Specific skills of estimating important molecules by UV-visible spectroscopy
CO3: Methods to analyse the amount of carbohydrates, vitamin C, proteins, steroids, urea and drugs like aspirin in samples
CO4: Synthetic skills to plan and execute multi step protocols
CO5: Monitoring of reaction progress and purification and identification of intermediates
CO6: Conformation of the target structure and estimation of its purity level</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

<table>
<tr><th>Unit No.</th><th>Contents</th><th>Contact Hrs.</th></tr>
<tr><td>I</td><td>QUANTITATIVE ANALYSIS
UV-vis spectrophotometric estimations of the followings:
● Carbohydrates
● Ascorbic acid
● Amino acids</td><td>30</td></tr>
<tr><td>II</td><td>QUANTITATIVE ANALYSIS
Estimations of the followings:
● Proteins
● Cholesterol
● Urea
● Aspirin</td><td>30</td></tr>
</table>

III	**MULTI-STEP ORGANIC SYNTHESIS** Prepare at least any two organic compounds by three or more step reaction. [**Important** ***Note:*** *Prefer to use* ***greener protocols*** *wherever possible. Monitor the progress of reaction by TLC and submit the recrystallised sample of the synthesized compound after checking its purity by TLC at each step*]	30

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1st Edition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

Course No: CH-35	Course Name: Organic Chemistry Practical-V						Course Code: SBS CH 010419 DSE 0063		
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** 06		
			0	0	6	3	**Total Hours:** 90		
Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks		**Examination Duration:** 8 Hrs. **Pre-requisite of course:** General and basic skill of the working principle of FTIR and NMR spectroscopy and mass spectrometry by analysing samples. General synthetic skills using microwave-mediated and mechanochemical organic synthesis.							
Course Objective	To acquire knowledge and skill for the identification of samples of purified unknown organic compounds by measuring and analysing various spectra. Ability to handle spectroscopy equipment such as FTIR, UV-visible, NMR and MS. Ability to process and interpret the obtained spectral data and report it according to standard conventions. Collective use of the obtained information to arrive at a possible structure and molecular formula. Learn to execute modern green methods such as microwave and mechanochemical methods in targeted synthesis.								
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Theoretical and practical knowledge about various spectroscopic techniques **CO2:** Hands on skills with FTIR and UV-visible spectrophotometers **CO3:** Process, analyse and report IR and UV spectral data and use it in structure determination **CO4:** Skills to process, analyse and report NMR and MS data output and apply it for structure determination **CO5:** Plan and execute microwave mediated synthesis **CO6:** Plan and execute mechanochemical organic synthesis								

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**SPECTROSCOPIC IDENTIFICATION OF FUNCTIONAL GROUPS OF ORGANIC COMPOUNDS** Determine the functional groups present in the compound by measuring and analysing the FTIR and UV-visible spectra. Report the spectral data in a standard format.	30
II	**SPECTROSCOPIC ANALYSIS OF ORGANIC COMPOUNDS ON BASIS OF NMR AND MS TECHNIQUES** Obtain and interpret the NMR spectra (H, C and F if necessary), process the spectra, report it based on conventions. Obtain the mass spectra and report it in a standard format. Analyse all the available data and arrive at a possible structure and molecular formula.	30

III	**MICROWAVE-MEDIATED AND MECHANOCHEMICAL ORGANIC SYNTHESIS** Synthesis of target compounds by using non-conventional energy sources such as microwave, grinding, ball milling or sonochemical methods. Identification and purity determination of the synthesized compounds.	30

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

Course No: CH-36	Course Name: Organic Chemistry Practical-VI	Course Code: SBS CH 010420 DSE 0063

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 6
2022 onwards	M.Sc. Chemistry	IV	0	0	6	3	Total Hours: 90

Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks	**Examination Duration: 8 Hrs.** **Pre-requisite of course:** This course will develop basic skills for designing and synthesizing multi-step organic synthesizing and their characterization of intermediates using spectroscopic techniques.
Course Objective	*To analyse a complex synthetic problem in its entirety. Identify the key structural elements, stereochemical features and challenges in the given target molecule. Design the strategy, tactics and execute the synthesis in shortest possible way. Isolate, purify and identify each of the intermediates. Characterise any unknown compounds completely. Confirm the identity and purity of the final compound with all available techniques.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Ability to analyse a given structure and establishing its key features **CO2:** Design the strategy and tactics of a possible synthesis **CO3:** Decide on the best possible approach by considering protecting group free, green and economically viable routes **CO4:** Execute the synthesis step by step, isolate and analyse each intermediate **CO5:** Troubleshoot and innovate when faced with roadblocks **CO6:** Isolate, purify and conform the structure of final target with all available means

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I-III	**RETROSYNTHETIC ANALYSIS, SYNTHESIS, AND SPECTROSCOPIC CHARACTERISATION OF ALL INTERMEDIATES AND THE TARGET COMPOUND** [**Important *Note:*** *Prefer to use greener protocols wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and m.pts.*]	90

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback*, Pearson*, 2003.

9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

PHYSICAL CHEMISTRY COURSES

THEORY COURSES

<table>
<tr><td colspan="2">Course No:
CH-03</td><td colspan="3">Course Name:
Physical Chemistry-I</td><td colspan="5">Course Code:
SBS CH 010103 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2" colspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of basic chemistry up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="9">To provide students with a basic understanding of thermodynamics, fugacity, phase rule, essentials of chemical kinetics and principle of quantum mechanics. This course will strengthen the fundamentals of Physical Chemistry, especially thermodynamics and quantum chemistry.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: Basic understanding of physical chemistry.
CO2: Use of thermodynamics and chemical kinetics in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important methods.
CO5: Development of alternate and new theoretical methods.
CO6: Use of advanced and recent technologies in physical chemistry.</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.
ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO PHYSICAL CHEMISTRY AND CLASSICAL THERMODYNAMICS** Logarithmic relations, Curve sketching and linear graphs, calculation of slopes, terms of mean and median, Precision and accuracy in chemical analysis, types of error, standard deviation, Numerical Problems. ***Classical Thermodynamics:*** Its Laws, Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities like entropy, enthalpy, free energy; Gibb`s-Duhem equation; Clausius-Clapeyron equation, Nernst heat theorem, Chemical potential and Work Function.	15
II	**ACTIVITY, FUGACITY, PHASE RULE** Concepts of fugacity, fugacity of gases and its determination. Activity and activity coefficient, choice of standard states, determination of activity coefficient for solute and solvent. ***Phase Rule:***	15

	Phase Rule and its determination, application, Phase diagram for one component system, for two completely miscible components systems like Pb-Ag system, KI+ H_2O system, Bi-Cd system, Ferric chloride + water system, Sodium chloride + water system, Na_2SO_4-H_2O system.	
III	**CHEMICAL KINETICS-I** ***Introduction to Chemical Kinetics*****:** Methods of determining rate laws, Arrhenius equation and its theory, Collision theory, and activated complex theory. ***Chain Reactions*****:** Hydrogen-bromine reaction, Pyrolysis of acetaldehyde, Decompositions of ethane. Photochemical reactions (hydrogen-bromine and hydrogen-chlorine reactions). General treatment of chain reaction (hydrogen- bromine reactions), Apparent activation energy of chain reactions, Chain length, Rice-Herzfeld mechanism of organic molecules decomposition (acetaldehyde).	15
IV	**PRINCIPLES OF QUANTUM MECHANICS** Introduction to Quantum Mechanical Approach, Quantum Mechanical operators, Eigenvalues of Quantum Mechanical operators, Hermitian operator, Ladder operator, commutation relations, postulates of quantum mechanics and Uncertainty Principle. Dirac delta function, Uncertainty in position and momentum, Schrödinger equation for finding wave function of a particle, Energy of a particle in One-Dimension box, Extension to Schrödinger equation for finding wave function in a three-dimensional box, Energy of a particle in Three-Dimension box, Energy levels, Eigenvalue, concept of degeneracy and selection rules.	15

Suggested Readings:

1. J.P. Lowe, and K. Peterson, Quantum Chemistry, *Academic Press*, 2019.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press,* 2014
4. I. N. Levine, Quantum Chemistry, 7th Edition. *Pearson Education*, 2013.
5. I. N. Levine, Physical Chemistry, 6th Edition. *Tata Mcgraw-Hill Education*, 2011.
6. D. Mcquarie and J. Simon, Physical Chemistry-A molecular approach, 1st Edition. *Viva*, 2010.
7. R. K. Prasad, Quantum Chemistry, *New Age International*, 2010.
8. A. K. Chandra, Introductory Quantum Chemistry, *Tata McGraw-Hill*, 2008.
9. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 2007.
10. E. Kreyszig, Advanced Engg. Mathematics, *John Wiley & Sons, Inc*. 2006.

Course No: CH-09	**Course Name:** Physical Chemistry-II (Quantum Chemistry & Group Theory)				**Course Code:** SBS CH 010209 C 4004			
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** **04**	
			4	0	0	4	**Total Hrs.:** **60**	
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.						
Course Objectives	*To provide students with an understanding of physical chemistry like quantum approach, enzyme kinetics, unimolecular reactions, principles of symmetry and group theory and non-equilibrium thermodynamics. This course will strengthen the essentials of Physical Chemistry, especially group theory and quantum chemistry.*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of physical chemistry. **CO2**: Use of symmetry and enzyme kinetics in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate and new theoretical methods. **CO6**: Use of advanced and recent technologies in Physical Chemistry.							

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**QUANTUM APPROACH AND APPROXIMATION METHODS** ***Harmonic oscillator***: Application to diatomic molecules and Energy levels. Properties of Legendre polynomials, Rodrigues formula, Recursion formulae, Associated Legendre polynomials, Laguerre and associated Laguerre polynomials. ***Rigid rotator***: Model for a rotating diatomic molecule and Energy level. Solution of spherical eigen-functions, Recursion formulae, Derivation of Legendre polynomial equation. ***The Hydrogen atom***: Schrödinger equation for hydrogen atom. Solution of radial wave function. Radial distribution curves and shapes of atomic orbitals. ***Approximate Methods***: The linear variation principle, First order time-independent Perturbation theory for non-degenerate states. Variation theorem and variation methods. Use of these methods illustrated with some examples like particle in a box with finite barrier, anharmonic oscillator, approximation functions for particle in a box and hydrogen atom.	15

II	**ENZYME KINETICS AND THEORY OF UNIMOLECULAR REACTIONS** ***Enzyme Kinetics***: Kinetics of (one intermediate) enzymatic reaction: Michaelis-Menton treatment, Evaluation of Michaelis's constant for enzyme-substrate binding by line weaver-Burk plot by Dixon and by Eadie-Hofstee methods. Competitive and non-competitive inhibition. ***Unimolecular reactions***: Dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions.	15
III	**PRINCIPLES OF SYMMETRY AND GROUP THEORY** Symmetry elements and Symmetry operations; Definitions of groups, subgroups, and classes; Symmetry elements in Allene, H_2O_2, Benzene and Ferrocene; Determination of point groups of small molecules and Schönfliesand Hermann-Mauguin Notations; The Great Orthogonality theorem. Character table for point group C_n (C_2v and C_3v), D_n, (n=2 and 3), T_d and O_h.	15
IV	**NON EQUILIBRIUM THERMODYNAMICS** General theory of non-equilibrium processes, Entropy production and entropy flow; Thermodynamic criteria for non-equilibrium states, Entropy production in heat flow, Mass flow, Electric current, Chemical reactions, Saxen's relation, Onsager's reciprocity relation, Thermomolecular pressure difference, Electro kinetic phenomenon, Coupled reactions.	15

Suggested Readings:

1. F. A. Cotton, Chemical Application of Group Theory, 3rd Edition. *John Willey & Sons*, 2018.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
4. I. N. Levine, Quantum Chemistry, 7th Edition. *Pearson Education*, 2013.
5. C. Kalidas and M. V. Sangaranarayanan, Non-Equilibrium Thermodynamics: Principles & Applications, *Macmillan India Ltd.*, 2012.
6. R. K. Prasad, Quantum Chemistry, *New Age International*, 2011.
7. A. K. Chandra, Introductory Quantum Chemistry, *Tata McGraw-Hill*, 2008.
8. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 2007.
9. A. Katchalsky and P. F. Curren, Non-Equilibrium Thermodynamics in Biophysics*, Harvard University Press*, Cambridge, 1995.
10. G. Davidson, Group theory for Chemist, *Macmillan Physical Science*, 1991.

Course No: CH-13	Course Name: Molecular Spectroscopy	Course Code: SBS CH 010313 C 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	III	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic of molecular spectroscopy up to UG level.
Course Objectives	*To provide students with an understanding of the basics of molecular spectroscopy like rotational, vibrational, Raman, electronic and solid state and surface spectroscopy. This course will strengthen the essentials of molecular spectroscopy, especially microwave and infrared spectroscopy*.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of molecular spectroscopy. **CO2**: Use of spectroscopy in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important spectroscopic methods. **CO5**: Development of alternate and new spectroscopic characterization methods. **CO6**: Use of advanced and recent technologies in molecular spectroscopy.

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.
ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ROTATIONAL SPECTROSCOPY** ***Basics of Molecular Spectroscopy*** Electromagnetic radiation and its region, representation of spectra, signal to noise ratio, resolving power, width and intensity of spectral lines. ***Rotational (Microwave) Spectroscopy*** Rotational Spectroscopy-Rigid diatomic Rotator, Selection rule for rotational/microwave spectrum, determination of bond-length, intensity of spectral lines, effects of isotopes on rotational spectra, Non-rigid rotator, Stark effect, Rotational spectra of linear polyatomic molecules, Application of microwave spectroscopy.	15
II	**VIBRATIONAL AND RAMAN SPECTROSCOPY** ***Infrared (Vibrational) Spectroscopy*** Vibration in Diatomic molecules, Simple Harmonic Oscillator Model, Anharmonic Oscillator, Selection Rule, Population of Vibrational Energy level, Diatomic Vibrating Rotator, P-Q-R Branches of Spectra, Breakdown of Born Oppenheimer Approximation, Fundamental Vibration and their Symmetry, Overtone and Combination frequency, Applications of Infra-red spectroscopy. ***Raman Spectroscopy***	15

	Stokes and anti-Stokes lines. Polarizability ellipsoids. Pure Rotational Raman spectra, pure vibrational Raman spectra. Selection rules. Rule of Mutual Exclusion. Polarization of light, Raman Effect, Application of Raman and Infra-red spectroscopy in structure determination	
III	**ELECTRONIC SPECTROSCOPY** Principle of electronic spectroscopy, Total electronic angular momentum, Term symbol. Vibrational Coarse Structure: Progressions, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions, Fortrat diagram, Pre-dissociation.	15
IV	**SOLID STATE AND SURFACE SPECTROSCOPY** Electronic Energy loss Spectroscopy (EELS), Reflection-Absorption Infrared Spectroscopy (RAIRS), Photoelectron spectroscopy (PES): X-ray PES and Ultra-violet PES, Auger Electron Spectroscopy (AES) and X-ray Fluorescence (XRF).	15

Suggested Readings:

1. C. N. Banwell and E. M. McCash, Fundamental of Molecular Spectroscopy, 4thEdition. *Tata McGraw-Hill Publishing Company Ltd.*, New Delhi, 2017.
2. D. N. Satyanarayana, Handbook of Molecular Spectroscopy: From radio waves to gamma rays, *I. K. International Publishing House*, New Delhi, 2015.
3. R. Kakkar, Atomic & Molecular Spectroscopy*, Cambridge University Press*, 2015.
4. J. M. Hollas, Modern Spectroscopy, 4th Edition. *John Wiley & Sons*, 2014.
5. G. E. Bacon, Fifty Years of Neutron Diffraction*, Hilger*, 2007.
6. B. E. Warren, X-Ray Diffraction*, Dover Publications*, 1999.
7. J. C. D. Brand and J. C. Speakman, Molecular Structure: The Physical Approach,2nd Edition. *Edward Arnold*, London, 1995.
8. W. J. Moore, Physical Chemistry, 4th Edition. *Prentice-Hall*, 1992.
9. R. Chang, Basic Principles of Spectroscopy, *McGraw-Hill*, New York, 1990.

Course No: CH-25	**Course Name:** Physical Chemistry-III (Statistical Mechanics, Surface and Interface Chemistry)				**Course Code:** SBS CH 010309 DSE 4004		
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week:** **04** **Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.					
Course Objectives	*To provide students with an understanding of advanced physical chemistry like statistical mechanics and thermodynamics, photochemistry and electrified interface. This course will strengthen the essentials of Physical Chemistry, statistical mechanics and photochemistry.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of statistical mechanics and photochemistry in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate and new theoretical methods. **CO6**: Use of advanced and recent technologies in Physical Chemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**STATISTICAL MECHANICS** Concept of distribution, Thermodynamic probability and most probable distribution, Canonical, grand canonical and micro canonical ensembles. Maxwell-Boltzmann statistics, Boltzmann distribution, Derivation of the Boltzmann distribution expression, Determination of the Boltzmann constant, Maxwell distribution law of velocity from Boltzmann distribution expression, The Bose-Einstein statistics, Statistics of a photon gas, Fermi-Dirac statistics and comparison of three statistics.	15
II	**STATISTICAL THERMODYNAMICS** Partition function and thermodynamic properties, Factorization of partition function, Relationship of partition function to thermodynamic properties, Translational partition function, Calculation of absolute entropy of an ideal monoatomic gas, Secure-Tetrode equation. Vibrational and rotational partition function of diatomic molecules. Calculation of contribution of vibrational, rotational partition functions towards various thermodynamic properties. Electronic partition function, Effect of change of zero-point energy on partition function. Chemical equilibrium and equilibrium constant in terms of partition functions.	15
III	**PHOTOCHEMISTRY** Transitions between states (Chemical, classical and quantum dynamics, vibronic states). Potential energy surfaces, transitions between potential energy surfaces. The Franck-Condon principle and	15

	radiative transitions. Spin-orbit coupling and spin forbidden radiative transitions, delayed fluorescence and phosphorescence. Triplet-triplet, triplet-singlet, singlet-triplet energy transfer. Multiphoton energy transfer processes. Photoelectric effect, Compton effect. Energy transfer: theory of radiation less energy transfer, energy transfer by electron exchange.	
IV	**ELECTRIFIED INTERFACES** Thermodynamics of electrified interfaces, Electrocapillary thermodynamics, Non-polarizable interface and Thermodynamic equilibrium. Fundamental thermodynamic equation of polarizable interfaces. Determination of excess charge density on the electrode, electrical capacitance and surface excess of the interface, potential of zero charge, Helmholtz-Perrin model, Gouy-Chapman model, Stern and Devanathan model.	15

Suggested Readings:

1. B. Bagchi, Statistical Mechanics for Chemistry and Material Science, *CRC Press*, 2018.
2. T. L. Hill, An Introduction to Statistical Thermodynamics, *Dover Publication*, 2018.
3. R. K. Pathria and Paul D. Beal, Statistical Mechanics, 3rd Edition. *Elsevier*, 2016.
4. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed., 2015.
5. P. Atkins and J. P. Atkins' Physical Chemistry*,* 10th Edition. *Oxford University Press*, 2014.
6. D. McQuarie and J. Simon, Physical Chemistry-A molecular approach, 1stEdition.*Viva*, 2010.
7. D. A. McQuarrie, Statistical Mechanics, *Viva Books Pvt. Ltd.*, New Delhi, 2003.
8. A. Gilbert and J. Baggot, Essentials of Molecular Photochemistry, *Blackwell Scientific*, 1999.
9. N. J. Turro, Modern Molecular Photochemistry, *Univ. Science Books,* 1991.

Course No: CH-26	Course Name: Physical Chemistry-IV (Solid State & Electroanalytical methods)						Course Code: SBS CH 010310 DSE 4004
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** 04
			4	0	0	4	**Total Hrs.:** 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.
Course Objectives	*To provide students with an understanding of advanced physical chemistry like electrochemistry, electroanalytical and potentiometric methods and solid-state chemistry. This course will strengthen the essentials of Physical Chemistry i.e., electrochemistry and solid-state chemistry.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of electroanalytical and potentiometric methods in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in electrochemistry.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTROCHEMISTRY-II** Contact adsorption on the electrode, Free energy of contact adsorption, The degree of contact adsorption and the measurement of contact adsorption, The influence of the contact adsorption on the capacity of the interface, Capacity-potential curve, The position of the OHP and the constant capacity, The capacitance hump, Variation of the population of contact-adsorbed ions with electrode charge, The lateral-repulsion model and the water Flip-Flop model of contact adsorption, The contribution of adsorbed water dipoles to the capacity of the interface.	15
II	**ELECTRO-ANALYTICAL & POTENTIOMETRIC METHODS** Polarization phenomenon and its theories, Effect of concentration on cell potential. Concept of Liquid Junction potential. Reference electrodes (Calomel, Ag/AgCl, Tl/TlCl) Metallic Redox indicator electrode: Membrane and ion selective electrodes. Enzyme electrode. Constant current chronoamperometry, constant potential chronoamperometry, Pulse voltammetry. Electrocatalysis: Influence of various parameters on water splitting, HER and OER.	15
III	**SOLID STATE CHEMISTRY-I** Classification of solids, Lattice energy, Thermal decomposition reactions, Nucleation, Free energy of nucleation: Laws, Functions and growth of nuclei. Kinetic expressions for diffusion controlled,	15

	nucleation and growth-controlled reactions. Perfect and imperfect crystals, Point defects, Line and plane defects, Vacancies: Schottky and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, Color center, non-stoichiometric defects.	
IV	**SOLID STATE CHEMISTRY-II** Evaluation of Madelung constant (NaCl), Calculation of repulsive potential exponent: Lattice heat capacity. Einstein and Debye model of lattice heat capacity, Debye T^3 law. ***X-ray diffraction:*** Bragg condition, Miller indices, Laue method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, structure of simple lattices and X-ray intensities. JCPDS card file for corelating structure.	15

Suggested Readings:

1. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
2. P. Atkins and J. Paula, Atkins Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
3. D. Mcquarie and J. Simon, Physical Chemistry-A Molecular Approach, 1stEdition.*Viva*, 2010.
4. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I (Ionics), *Springer*, 2006.
5. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-II, *Springer*, 2006.
6. L. E. Smart, E. A. Moore, Solid State Chemistry-An Introduction, 3rd Edition. *CRC Press*, 2005.
7. A. R. West, Basic Solid-State Chemistry, 2nd Edition. *John Wiley & Sons*, 2005.

Course No: CH-37	Course Name: Physical Chemistry-V (Polymer & Surface Chemistry)	Course Code: SBS CH 010421 DSE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	IV	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.
Course Objectives	*To provide students with an understanding of advanced physical chemistry like polymer chemistry, polymer characterization and chemistry of surfactants. This course will strengthen the fundamentals of Physical Chemistry, especially polymer chemistry and chemistry of surfactants.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of polymer chemistry and chemistry of surfactants in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in polymer chemistry.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**POLYMER CHEMISTRY** Classification of polymers, Polymerization: Condensation, Addition, Radical chain, Ionic, Coordination and Co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems. Kinetics of polymerization. Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. Meaning of glass transition temperature, T_g, factors influencing the glass transition temperature and importance of glass transition temperature.	15
II	**CHARACTERIZATION AND CONDUCTING POLYEMRS** The practical significance of molecular weight. Measurement of molecular weights: End-group, Osmotic and Ultracentrifugation methods. Analysis and testing of polymers: Chemical analysis of polymers, Spectroscopic methods and Microscopy. Thermal analysis and physical testing: Tensile strength, fatigue, impact, tear resistance and hardness and abrasion resistance. ***Electrically conducting polymers:*** Factors affecting the conductivity of conducting polymers, nature of charge carriers in conducting polymers: Solitons, polarons and bipolarons. Mechanism of conduction in polymers.	15

	Organic solids, fullerenes, molecular devices: organic superconductors, doped fullerenes as superconductors and magnetism in organic materials.	
III	**CHEMISTRY OF SURFACTANTS-I** Adsorption of surface-active agents at Solid/Liquid, Liquid/Gas and Liquid/Liquid interfaces. Mechanism of adsorption, adsorption isotherm, effects of adsorption from aqueous solution on the surface properties of solid adsorbent, adsorption from non-aqueous solution. Determination of surface areas of solids. Gibb's and BET adsorption equation and its utilization to calculate surface concentration and surface area per molecule. ***Thin films and Langmuir-Blodgett films:*** Preparation techniques, evaporating/sputtering, chemical process, MOCVD, Sol-gel, Langmuir-Blodgett (LB) film, growth techniques, properties and applications of LB films.	15
IV	**CHEMISTRY OF SURFACTANTS-II** Surface active agents, classification, Critical micelle concentration (CMC), Methods of determining CMC, Factors affecting CMC, Micellar structure and shape, Micellar aggregation. CMC in non-aqueous media. hydrophobic interaction, Krafft temperature, Thermodynamic parameters of micellization. Counterion binding to micelles, solubilization, microemulsions, reverse micelles, surface films (electro kinetic phenomenon), catalytic activity at surfaces. Effectiveness of adsorption at Liquid/Gas and Liquid/Liquid interfaces, Szyszkiwski, Langmuir, Temkin, and Frumkin adsorption equations. Derivation of thermodynamics parameters of adsorption at the Liquid/Gas and Liquid/Liquid interfaces.	15

Suggested Readings:

1. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, *New Age Internat. Pvt. Ltd.*, 2015.
2. F. W. Billmeyer Jr., Textbook of Polymer Science, *Wiley India Pvt. Ltd.*, 2014.
3. M. J. Rosen, Surfactants and Interfacial Phenomenon, 4thEdition. *Wiley*, 2012.
4. P. Becher, Emulsions: Theory and Practice, *American Chemical Society*, 2019.
5. H. R Alcock and F. W. Lamb, Contemporary Polymer Chemistry, *Prentice Hall*, 2017.
6. J. M. G. Cowie, Physics and Chemistry of Polymers, *Blackie Academic and Professional*, 2014.
7. F. Wold, Macromolecules: Structure and Function, *Prentice Hall of India*, 2001.
8. K. Takemoto, R. M. Ottanbrite and M. Kamachi, 2nd Edition. Functional Monomers and Polymers, *CRC press*, 1997.
9. P.C. Hiemenz, R. Rajagopalan, Principles of Colloid and Surface Chemistry, Revised and Expanded (Undergraduate Chemistry: A Series of Textbooks, 3rd Edition. *CRC Press*, 2007.
10. G. A. Somorjai, Y. Li, Introduction to Surface Chemistry and Catalysis, 2nd Edition. *Wiley*, 2010.

Course No: CH-38	Course Name: Physical Chemistry-VI (Frontiers in Electrochemistry)	Course Code: SBS CH 010422 DSE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2022 onwards	M.Sc. Chemistry	IV	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.
Course Objectives	*To provide students with an understanding of applied physical chemistry like Electrodics, Fuel cell, Supercapacitors and rechargeable Batteries, current potential laws and Corrosion of metals and their alloys, Liquid crystals. This course will strengthen the applications of Physical Chemistry, especially Fuel cells and Batteries and Corrosion.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An understanding of advanced Physical Chemistry. **CO2**: Use of Fuel cells and Batteries and Corrosion in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in Batteries and Corrosion.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTRODICS** Rate of charge transfer reactions under zero field, under the influence of an electric field. The equilibrium exchange current density, the non-equilibrium drift-current density (Butler-Volmer) equation. High-field and low-field approximations. Physical meaning of the symmetry factor (β), A simple picture of the symmetry factor and its dependence on over potential. Polarizable and nonpolarizable interfaces.	15
II	**FUEL CELLS, SUPERCAPACITORS AND BATTERIES** The maximum intrinsic efficiency, Actual efficiency and Current-Potential relation in an electrochemical energy converter. Factors influencing the electrochemical energy conversion, The power output of an electrochemical energy converter. Electrochemical electricity generators (fuel cells). Brief idea about H_2-O_2 fuel cell, Hydrocarbon-air fuel cells, and Natural gas, CO-air fuel cells, Supercapacitors, and Lithium ion batteries. Electricity storage: Some important quantities in electricity storage (like electricity storage density, energy density and power), Desirable conditions	15

	for an ideal storrer, Storage of electricity using the lead-acid battery, Dry cell, Silver-Zinc cell and Sodium-Sulfur cell.	
III	**CORROSION** Electrochemistry of corrosion of metals, Factors affecting corrosion, Electrochemical cell formation, Polarization of metal electrode *i.e*. Concentration, Resistance and Activation polarization. Anodic and cathodic polarization curves (Evan's diagram). Electrochemical measurement of corrosion current density, corrosion potential and mixed potential theory and Tafel slope. Impedance spectroscopy technique, Anodic passivation and passivation potential. Passivity theory. Methods of protecting metal and their alloys from corrosion (anodic protection, cathodic protection, sacrificial protection, barrier protection, use of chemical inhibitors, environment modifiers).	15
IV	**CURRENT POTENTIAL LAWS AND LIQUID CRYSTALS** Comparison of electrolytic interface to other type of charged interfaces *i.e.* semiconductors *p-n* junctions. The current across biological membranes, Hot and cold emission of electrons from a metal into vacuum. Dye sensitized solar cells. Liquid crystals: Mesomorphic behavior, thermotropic liquid crystals, positional order, bond orientational order, nematic and smetic mesophases, Smectic-nematic transition, twisted nematics, chiral nematics, optical properties of liquid crystals.	15

Suggested Readings:

1. M. G. Fontana, Corrosion Engineering, *McGraw Hill*, 2017.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. S. Glasstone, An introduction to Electrochemistry, *Est West Press Ltd*., 2016.
4. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I, *Springer*, 2009.
5. R. Narain, An Introduction to Metallic Corrosion, *Oxford and IBH Pub Co.*, 1993.
6. P. Atkins and J. Paula, Atkins' Physical Chemistry, *Oxford University Press*, 10th ed., 2014.
7. D. Mcquarie and J. Simon, Physical Chemistry-A Molecular Approach, 1stEdition. *Viva*, 2010.
8. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I (Ionics), *Springer*, 2006.
9. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-II, *Springer*, 2016.

PRACTICAL COURSES

<table>
<tr><td colspan="2">Course No: CH-06</td><td colspan="4">Course Name:
Physical Chemistry Practical-I</td><td colspan="3">Course Code:
SBS CH 010106 C 0042</td></tr>
<tr><td>Batch:
2022 onwards</td><td>Programme:
M.Sc. Chemistry</td><td colspan="2">Semester:
I</td><td>L
0</td><td>T
0</td><td>P
4</td><td>Credit
2</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50
CIE: 15 Marks
TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To train students with introductory physical chemistry practical like adsorption, saponification value, molecular weight determination, surface tension, viscosity, distribution law and thermochemistry.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of surface tension, viscosity, adsorption in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Depending on availability of time and equipment some experiments may be added/deleted.</td></tr>
</table>

<table>
<tr><th>Unit No.</th><th>Contents</th><th>Contact Hrs.</th></tr>
<tr><td>I</td><td>HANDS ON TRAINING IN PHYSICAL CHEMISTRY EXPERIMENTS
Partial Molar Quantities
• To determine the partial molar volume of urea and ethanol in aqueous solution from density measurements.
Adsorption
• To determine the adsorption isotherms of acetic acid from aqueous solution and I_2 from alcoholic solution by charcoal.
• To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal and to examine the validity of Freundlich & Langmuir's adsorption isotherms.
Acid and Saponification Value
• To find out the acid value of a given sample.
• To find out the saponification value of given vegetable oil.
Molecular Weight of Polymer
To determine the molecular weight of a given polymeric solution by viscosity and Rast method.</td><td>30</td></tr>
<tr><td>II</td><td>BASICS PHYSICAL CHEMISTRY EXPERIMENTS</td><td>30</td></tr>
</table>

	Surface Tension/Interfacial Tension ● To find surface tension/interfacial tension between two immiscible liquids. ● To determine the percentage composition of a given mixture of two liquids say CCl_4 and Toluene by surface tension method. Viscosity ● To find viscosity and coefficient of viscosity of unknown liquids by Ostwald's viscometer method. ● To determine the percentage composition of given unknown mixture by viscosity method. *Distribution Law* ● To study the distribution of benzoic acid, I_2, succinic acid between organic liquid and water at room temperature and show that whether BA, I_2, Succinic acid dimerizes in organic liquid or water. Thermochemistry ● To determine the heat of neutralization of sulphuric acid using Dewar's vacuum flask as the calorimeter. ● To determine the heat of ionization of a weak base i.e. NH_4OH using calorimeter.	

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. Saroj Kumar Maity, Naba Kumar Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1^{st}Edition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9^{th}Edition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

<table>
<tr><td>Course No:
CH-12</td><td colspan="5">Course Name:
Physical Chemistry Practical-II</td><td colspan="3">Course Code:
SBS CH 010212 C 0042</td></tr>
<tr><td>Batch:
2022 onwards</td><td>Programme:
M.Sc. Chemistry</td><td>Semester:
II</td><td>L
0</td><td>T
0</td><td>P
4</td><td>Credit
2</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students exposure of refractometry, chemical kinetics, solution chemistry, turbidity metry, and pH, potentio and conductometry experiments. Advanced experiments such as pH metry, potentiometry and conductometry will be carried out. First-hand experience of turbidity meter studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of pH meter, potentiometer, conductivity meter in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td colspan="2">Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">CHEMICAL KINETICS AND pH METRY EXPERIMENTS
Chemical Kinetics
● Determination of the effect of (a) change in temperature, (b) change in concentration of reactants and catalysts (c) ionic strength of the media on velocity constant of hydrolysis of an ester.
● Determine the velocity constant of hydrolysis of ethyl acetate catalyzed by an acid and NaOH solution.
Solution Chemistry
● To determine the solubility of an inorganic salt like KCl, NaCl, KNO_3, $NaNO_3$, K_2SO_4 in water at different temperature and hence to obtain the solubility curve.
● To determine the heat of solution of given substance like oxalic acid and benzoic acid by solubility method.
pH metric
● To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus weak base, strong acid versus weak base using a pH meter.</td><td colspan="2">30</td></tr>
</table>

	• To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate, $K_2Cr_2O_7$and $KMnO_4$ by a pH metric titration method.	
II	**POTENTIOMETRY AND CONDUCTOMETRY EXPERIMENTS** *Potentiometry* • To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus weak base, strong acid versus weak base using a potentiometer. • To prepare and test the standard reference electrode i.e., calomel electrode or silver- silver chloride electrode. • Titrate Mohr's salt against $KMnO_4$potentiometrically and carry out the titration in reverse order. *Turbidimetry* • To find the turbidity of given solution by using Nephthalo turbidity meter. *Conductometry* • Study of conductometric titration of NH_4Cl versus NaOH solution, CH_3COONa versus HCl, $MgSO_4$ versus $Ba(OH)_2$, $BaCl_2$ and $K_2SO_4$and comment on the nature of graph. • To study stepwise neutralization of polybasic acid like oxalic acid, citric acid, phosphoric acid by conductometric titration and explain the variation in the graph.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

<table>
<tr><td>Course No:
CH-27</td><td colspan="4">Course Name:
Physical Chemistry Practical-III</td><td colspan="4">Course Code:
SBS CH 010311 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:
M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td colspan="2">Total Hrs.: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 75
CIE: 22.5 Marks
TEE: 52.5 Marks</td><td colspan="7">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students exposure of solution chemistry, phase rule, spectrophotometry, polarimetry, ultrasonic interferometry and pH metry, potentiometry and conductometry experiments. Advanced experiments such as ultrasonic interferometer and spectrophotometer will be carried out. First-hand experience of polarimetric studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of pH meter, potentiometer, conductivity meter in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td colspan="2">Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">CONDUCTOMETRY AND pH METRY
Conductometry
● Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO_3, $AgNO_3$ and NaCl and the validity of Onsager equation.
● Determination of the solubility of lead sulfate and silver halides.
● Conductometric titration of Strong acid vs. strong base, weak acid vs. strong base, Strong acid vs. weak base, weak acid vs. weak base using conductivity meter.
pH metric
● Acid base titration of a non-aqueous media using pH meter.
● Determination of dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
● To determine the strength of strong acid versus weak base (NH_4OH), weak acid versus weak base, strong and weak acid mixture against a weak base using a pH meter.</td><td colspan="2">30</td></tr>
</table>

	• To determine the degree of hydrolysis and hydrolysis constant of aniline, acetic acid by pH metrically.	
II	**SPECTROPHOTOMETRY AND POLARIMETERY** *Spectrophotometry* • Determine the concentration of Crystal violet and Aurine in mixture of (Crystal violet + Aurine) solution. • To determine the dissociation constant (K_a)of Methyl red using UV-visible absorption spectrophotometer. • Verification of Beer law using solutions such as I_2 in CCl_4, and $CuSO_4$ in water, $K_2Cr_2O_7$ and $KMnO_4$ in sulphuric acid medium.	30
III	*Polarimetry* • To determine the concentration of an optically active substance using polarimeter. • To determine the percentage of two optically active substances in a given mixture. *Solution Chemistry* • Determination of Solubility by evaporation and gravimetric method. • Determination of transition temperature by thermometric method.	30

Suggested Readings:

1. B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

<table>
<tr><td>Course No:
CH-28</td><td colspan="4">Course Name:
Physical Chemistry Practical-IV</td><td colspan="3">Course Code:
SBS CH 010312 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td>3</td><td>Total Hrs.: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="6">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students exposure of phase rule, ultrasonic interferometry and pH metry, potentiometry and conductometry experiments. Advanced experiments such as ultrasonic interferometer and spectrophotometer will be carried out. First-hand experience of polarimetric studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of phase rule, ultrasonic interferometer, conductivity meter in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">PHASE RULE AND ULTRASONIC INTERFEROMETER
Phase Rule
● To verify the phase rule for a given two and three component Azeotropic mixtures.
● To determine the transition temperature of given salt hydrate like Sodium sulphate, Strontium sulphate or Sodium thiosulphate.
Ultrasonic Interferometer
● To find ultrasonic speed of given organic binary liquid mixtures of different composition.
● To study the effect of temperature on ultrasonic speed of given organic mixture.</td><td>30</td></tr>
<tr><td>II</td><td colspan="6">POTENTIOMETRY-I EXPERIMENTS
Potentiometry
● To determine the thermodynamic parameters for a reaction from EMF measurement.
● To determine the pH of a series of buffer solutions by potentiometric method.
● To determine the solubility product of AgCl and to determine instability constant of $Ag(NH_3)_2^+$ complex.</td><td>30</td></tr>
</table>

	• To determine the activity of hydrogen ion in acid medium using hydrogen electrode, hence to determine the ionic product of water and hydrolysis constant of sodium acetate. • To determine the degree of hydrolysis and hydrolysis constant of weak acid by potentiometry.	
III	**MAGNETIC MOMENT AND MAGNETIC SUSCEPTIBILITY** • Determine the magnetic susceptibility of a paramagnetic substance using Gouy's Balance. • To study the change in weight of a substance after passing magnetic lines of force. **POTENTIOMETRY-II EXPERIMENTS** • To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate and Ceric sulphate by a potentiometric redox titration. • To determine the amount of KI and KCl present in a mixture by potentiometric titration.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

<table>
<tr><td>Course No:
CH-39</td><td colspan="5">Course Name:
Physical Chemistry Practical-V</td><td colspan="3">Course Code:
SBS CH 010423 DSE 0063</td></tr>
<tr><td>Batch:
2022 onwards</td><td>Programme:
M.Sc. Chemistry</td><td>Semester:
IV</td><td>L
0</td><td>T
0</td><td>P
6</td><td colspan="2">Credit
3</td><td>Contact Hrs. per Week: 06
Total Hrs.: 90</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="7">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students exposure of Flame photometry, theoretical (computational) techniques, chronopotentiometry, chromatography, and conductometry experiments. Advanced experiments such as chronopotentiometry and computational will be carried out. First-hand experience of chronopotentiometry will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of flame photometer, computational techniques, chronopotentiometry in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Depending on availability of time and instruments available in laboratory, few experiments may be added/deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">FLAME PHOTOMETRY AND COMPUTATIONAL TECHNIQUES
● Determination of Na^+ and K^+ ions when present together.
● Determination of Li/Ca/Ba/Sr ions present in any analyte.
Computational Techniques
● Elementary exercise in computer graphics an illustrative experiment solving the interactive equation.
● Plotting a graph in origin.
● Drawing a structure of molecules in Avogadro software and molecular modelling.</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">CHROMATOGRAPHY AND CONDUCTOMETRY
● To prepare citric acid from sodium citrate and aniline from aniline hydrochloride using cationic and anionic exchangers.
● To differentiate common sugars/amino acids by paper chromatography.
Conductometry</td><td>30</td></tr>
</table>

	• Titrate a moderately strong acid (Salicylic/Mandelic acid) by the salt line and double alkali method. • Titrate a mixture of copper sulphate, acetic acid and sulphuric acid with sodium hydroxide. • Titrate magnesium sulphate against $BaCl_2$ and its reverse reaction.	
III	**CHRONOPOTENTIOMETRY TECHNIQUES** • Determine the extent of catalytic activity of Pt and Cu electrode by H_2 evolution reaction (HER). • Determine the extent of catalytic activity of Pt and Cu electrode by O_2 evolution reaction (OER). • Determine the area and roughness factor of the electrode by H-adsorption and H-desorption.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

<table>
<tr><td colspan="1">Course No:
CH-40</td><td colspan="5">Course Name:
Physical Chemistry Practical-VI</td><td colspan="3">Course Code:
SBS CH 010424 DSE 0063</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td colspan="2">Credit</td><td>Contact Hrs. per Week: 06</td></tr>
<tr><td>0</td><td>0</td><td>6</td><td colspan="2">3</td><td>Total Hrs.: 90</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 75

CIE: 22.5 Marks

TEE: 52.5 Marks</td><td colspan="6">Examination Duration: 8 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students exposure of nanotechnology experiments. Advanced experiments such as electrochemical methods and sol-gel, co-precipitation method will be carried out. First-hand experience of nanotechnology will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of practical physical chemistry.
CO2: Use of electrochemical, Sol-gel, Coprecipitation methods in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Depending on availability of time and instruments available in the laboratory, few experiments may be added/deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">SYNTHESIS OF NANOPARTICLES
• Synthesize metal nanoparticles by sol-gel method.
• Synthesize metal nanoparticles by co-precipitation method.
• Synthesize metal nanoparticles by reverse micelle technique.
• Extract metal nanoparticles from plants and their products like Mg from chlorophyll.</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">ELECTROCHEMICAL TECHNIQUES
• Record anodic and cathodic polarization of metal electrode in acidic medium.
• Find corrosion rate from Tafel plots using Stern-Gerry equation.
• Record Nyquist and Bode plots for MS electrode dipped in acidic medium.
• Record cyclic Voltammogram and find anodic and cathodic oxidative peak.
• Verify Cottrell equation using potential step chronoamperometry.</td><td>30</td></tr>
<tr><td>III</td><td colspan="7">CHARACTERIZATION TECHNIQUES
• Characterization of metal nanoparticles by UV-visible and FTIR spectroscopy techniques.
• Estimate direct and indirect optical energy band gap of metal nanoparticles by UV-visible spectroscopy technique.</td><td>30</td></tr>
</table>

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC)

Course No: CH-43	Course Name: Reaction Mechanism: Structure and Reactivity						Course Code: SBS CH 010101 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week:** **02** **Total Hrs.:** **30**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration:** 2Hrs. **Pre-requisite of course:** Basic and advance knowledge of Physical Organic Chemistry.						
Course Objective	*To provide a basic and advanced knowledge of physical organic chemistry including a better understanding of a reaction mechanism, kinetic and non-kinetic methods, the different types of reactive intermediates involved during a chemical reaction, and kinetic and thermodynamically controlled reactions.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Fundamental understanding of a reaction mechanism. **CO2**: Basic idea of a reactive intermediate involved during a chemical reaction. **CO3**: Basic knowledge of a kinetic and thermodynamic controlled product formation. **CO4**: Basic knowledge of kinetics and non-kinetics method to study a reaction mechanism. **CO5**: Idea about the correlation of stereochemistry and mechanism **CO6**: Advanced knowledge about general physical organic chemistry principles						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**FUNDAMENTALS OF REACTION MECHANISMS** Fundamentals of stereoelectronic effects and reactivity, acids and bases, reaction types, intermediates and transition state, effect of temperature and catalysts.	7
II	**REACTIVE INTERMEDIATES** Introduction to structure, formation, stability and reactions of carbocations, carbanions, free radicals, radical anions, radical cations, arynes, carbenes and nitrenes.	8
III	**CHEMICAL EQUILIBRIA AND REACTIVITY** Thermodynamic and kinetic control of reactions, Correlation of reactivity with structure, linear free energy relationships, Hammond’s postulate, Curtin-Hammett principle.	7
IV	**KINETICS AND NON-KINETIC METHODS TO STUDY MECHANISM** Kinetic methods: primary and secondary kinetic isotopic effects, isotopic labeling; non-kinetic methods: detection and interception of intermediates, systematic structural variation, stereochemical studies and cross-over experiments.	8

Suggested Readings:

1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A, 5th Edition, Springer, 2012.
2. E. V. Anslyn and D. A. Dougherty, Modern Physical Organic Chemistry, University Science Books, 2005.
3. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2nd Edition, Oxford University Press, 2001.
4. J. March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure, 4th Edition, John-wiley, 1999.
5. N. S. Isaacs, Physical Organic Chemistry, 2nd Edition, Longman Scientific & Technical, 1995.
6. P. Sykes, A guidebook to Mechanism in Organic Chemistry, 5th Edition, Longman Scientific Technical, 1985.
7. P. Deslongchamps, Stereoelectronic Effects in Organic Chemistry, Pergamon, 1983.

Course No: CH-44	Course Name: Nuclear Chemistry						Course Code: SBS CH 010102 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of *course:***To provide the basic knowledge of nuclear structures, radioactivity and applications.					
Course Objectives	*To provide the basics of nuclear structures, radiations, artificial radioactivity and applications of nuclear chemistry, radiopharmacy and chelation therapy.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of nuclear structure **CO2**: To identify and understand various nuclear reactions **CO3**: Measurement of radioactivity **CO4**: Artificial radioactivity **CO5**: To understand chelation therapy **CO6**: Applications of nuclear chemistry						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**NUCLEAR STRUCTURE** Composition of the nucleus, nuclear size, shape and density, theories of nuclear composition, magnetic and electric properties of nucleus, nuclear spin and parity, nuclear binding forces.	7
II	**NUCLEAR REACTIONS** Penetration potential, nuclear binding energy, nuclear emissions, nuclear transformations, bombardment of nuclei, nuclear fission, nuclear fusion, nuclear explosives, nuclear reactors in India, Szilard–Chalmer's effect, fuel cycle and waste management, reactor power control.	8
III	**RADIOACTIVITY** Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Measurement of radioactivity, group displacement law, radioactive disintegration series, rate of disintegration, half-life, average life of radioactive elements, unit of radioactivity, nuclear decay, determination of decay constants, decay rates, types of nuclear decay.	7

IV	**ARTIFICIAL RADIOACTIVITY AND APPLICATIONS OF NUCLEAR CHEMISTRY** Discovery of artificial radioactivity, isotopes used in medicines, radiocarbon dating, age determination, effects of radiation on life, applications of tracer element in medical, agriculture and analytical fields, biological effects of radiation, radiation protections, chelation therapy.	8

Suggested Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rd Edition. *Willey*, 2013.
2. W. D. Loveland, D. Morrissey and G. T. Seaborg, Modern Nuclear Chemistry, *John Wiley & Sons*, 2006.
3. C. E. Housecroft and A. G. Sharpe; *Inorganic Chemistry*, 2nd Edition. *Pearson*, 2005.
4. H. J. Arnikar, Essentials of Nuclear Chemistry, *Wiley Eastern*, 1988.

Course No: CH-45	Course Name: Green Chemistry						Course Code: SBS CH 010303 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 02**
			2	0	0	2	**Total Hrs.: 30**

Total Evaluation Marks:50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2Hrs. **Pre-requisite of course:** Basic knowledge of writing balanced chemical reactions. Basic understanding of nature of solvents, catalysts, chromatography and electromagnetic spectrum.
Course Objectives	*To provide the basic knowledge of Green Chemistry and its applications in the field of chemical sciences.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of green chemistry **CO2**: Use of greener and renewable catalysts and their applications **CO3**: Skills for analyzing and developing new sustainable methods **CO4**: Skills for developing industrially important methods **CO5**: Development of alternate and new eco-friendly synthetic pathways to chemicals **CO6**: Use of advanced and recent green technologies in organic synthesis

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO GREEN CHEMISTRY** Green chemistry history, needs and goals. Limitation/Obstacles in pursuit of the goals of green chemistry. Opportunities for next generation designer materials to create safer future. Twelve principles of Green Chemistry and their illustrations with examples.	7
II	**GREEN CATALYSIS AND RENEWABLE RAW MATERIALS** Heterogeneous catalysis: Use of zeolites, silica, alumina, clay, polymers, cyclodextrin and supported catalyst; Phase-transfer catalysis; Biocatalysis using enzymes; Biomass conversion to fine chemicals.	8
III	**GREENER SOLVENTS** Reactions under aqueous medium: Enhancement of selectivity, efficiency and industrial applicability. Ionic liquids; Supercritical fluids; Solvent free reactions in solid and liquid phase; Alternatives in extraction and chromatography.	7

IV	**GREEN TECHNOLOGY AND FUTURE TRENDS IN GREEN CHEMISTRY** Microwave and Ultrasound assisted reactions; photochemical reactions using sunlight; Flow techniques; combinatorial green chemistry. Green synthesis of ibuprofen and adipic acid (traditional vs green ones).	8

Suggested Readings:

10. G. Brahmachari, Catalyst-free Organic Synthesis. *Royal Society of Chemistry*, 2018.
11. M. Lancaster, Green Chemistry: An Introductory Text,3rd Edition. *Royal Society of Chemistry*, 2016.
12. F. M. Kerton, Alternative Solvents for Green Chemistry. *Royal Society of Chemistry*, 2013.
13. R. A. Sheldon, I. Arends and U. Hanefeld, Green Chemistry and Catalysis, 1stEdition. *Wiley-VCH*, 2007.
14. M. A. Ryan and M. Tinnes, Introduction to Green Chemistry. *American Chemical Society*, 2003.
15. P. T. Anastas and J. C. Warner, Green Chemistry: Theory and Practice. *Oxford University Press*, 1998.

Course No: CH-46	Course Name: Carbohydrate Chemistry and its Applications						Course Code: SBS CH 010304 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of writing chemical formulae, their interconversion and stereochemistry of substituted cyclohexane. Understanding of common reactions of aldehydic and ketonic functional groups.					
Course Objectives	*To provide the knowledge of chemistry of carbohydrates, their reactions and applications*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of carbohydrates **CO2**: In-depth understanding of carbohydrates and their reactions **CO3:** Important aspects of carbohydrates associated with human health **CO4**: Skills to design and create products and solutions to real life problems **CO5**: Understanding the role of carbohydrates in other allied fields **CO6**: Ability to analyse, design and solve problems based on carbohydrates						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**CARBOHYDRATES-I** Introduction and biomedical Importance, Classification: Monosaccharides, oligosachharides and polysaccharides, Sugars and non-sugars, Reducing and non-reducing sugars. Monosaccharides: Nomenclature, Structural representation, Isomerism. Physical and chemical properties of some important monosaccharides including stereochemical aspects wherever needed.	7
II	**CARBOHYDRATES-II** Synthesis of glucose and fructose. Oligosaccharides: Nomenclature and important terminology, Structural representation, Isomerism, physical and chemical properties of some important disaccharides (lactose, maltose and sucrose).	8
III	**CARBOHYDRATES-III** Polysaccharides: Nomenclature and important terminology, Homo and heteroploysaccharides, Structural representation. Physical and chemical properties of some important polysaccharides (Cellulose, Starch, Chitin). Glycolysis: Metabolism of Glucose.	7

IV	**CARBOHYDRATES-IV** Applications: Importance of monosaccharides and their derivatives like deoxy sugars, glycosides, myoinositol, amino sugars, *N*-acetylmuramic acid, sialic acid in different fields. Importance of oligosaccharides and polysaccharides in different sectors. Artificial sweeteners: Synthesis and importance.	8

Suggested Readings:

1. P. Y. Bruice, Organic Chemistry, 5th Edition. *Pearson Education*, 2014.
2. M. Sinnott, Carbohydrate Chemistry and Biochemistry: Structure and Mechanism, 2nd Edition. *Royal Society of Chemistry*, 2013.
3. P. Y. Bruce and K. J. R. Prasad, Essential Organic Chemistry, *Pearson Education*, New Delhi, 2008.
4. T. K. Lindhorst, Essentials of Carbohydrate Chemistry and Biochemistry, 3rd Edition, *Wiley*, 2007.
5. A. L. Lehninger, D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 4th Edition. *W. H. Freeman*, 2004.
6. M. Loudon, Organic Chemistry, *Oxford University Press*, New Delhi, 2002.

<table>
<tr><td>Course No:
CH-47</td><td colspan="5">Course Name:
Asymmetric Catalysis: Fundamentals to Frontiers</td><td colspan="3">Course Code:
SBS CH 010305 DCE 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="2">Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic knowledge of writing chemical formulae, their interconversion and stereochemistry. Basic understanding of homogenous and heterogeneous catalysis.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide the advanced knowledge of asymmetric catalysis in organic synthesis.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic and in-depth understanding of asymmetric synthesis
CO2: Use of catalysts and their applications in the field of asymmetric synthesis
CO3: Understanding of advanced stereochemical synthetic methods
CO4: Skills for developing pharmaceutically important methods for chiral compounds
CO5: Understanding of new eco-friendly synthetic pathways to chiral chemical compounds
CO6: Ability to analyse, design and solve problems based on asymmetric induction</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**ASYMMETRIC INDUCTION AND CATALYSIS** Asymmetric induction, modes of asymmetric induction, asymmetric catalysis and basics of asymmetric catalysis including energetic of reactions, Important factors affecting asymmetric catalysis.	7
II	**LEWIS ACID -BASE CATALYSIS AND CHIRAL AUXILLIARIES** Lewis acid and Lewis base catalysis including examples. Chiral auxiliary: Basic requirements of chiral auxiliary; Chiral pool sources: selected examples of few most common chiral auxiliaries (Oppolzer, Evans oxazolidones, Myers amides, 8-phenylmenthol).	8
III	**KINETIC RESOLUTION, DESYMMETRIZATION AND MECHANISTIC STUDIES** Kinetic, dynamic kinetic and parallel kinetic resolution; Desymmetrization reactions. Mechanistic studies of asymmetric reactions	7
IV	**MULTIFUNCTIONAL AND MODERN ASPECTS OF ASYMMETRIC CATALYSIS** Non-liner effects and Chiral amplifications. Bifunctional, dual and multifunctional catalyst Modern aspects of asymmetric catalysis: Counteranion directed catalysis, cooperative catalysis, dual and merged catalysis, asymmetric photocatalysis.	8

Suggested Readings:

1. E. M. Carreira, L. Kvaerno, Classics in Stereoselective Synthesis, *Wiley-VCH: Weinheim*, Germany, 2009.
2. M. Nogrady, Stereoselective Synthesis: A Practical Approach, *Wiley*, 2008.
3. P. J. Walsh, M. C. Kozlowski, Fundamentals of Asymmetric Catalysis, *University Science Book*, 2009.
4. A. Berkessel, H. Groger, Asymmetric Organocatalysis: From Biomimetic Concepts to Applications in Asymmetric Synthesis, *Wiley-VCH*, 2005.
5. I. Ojima, Catalysis in Asymmetric Synthesis, *Wiley-VCH*, 2004.
6. Recent review and research articles relevant to above topics (reprints to be handed over to students).

Course No: CH-48	Course Name: Supramolecular Chemistry						Course Code: SBS CH 010306 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** 02
			2	0	0	2	**Total Hrs.:** 30

Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of non-covalent interactions, lock and key analogy and host-guest systems.
Course Objectives	*To provide the basic knowledge of Supramolecular Chemistry, the terminologies, design and concepts and applications.*
Course Outcomes:	After completing this course, studentsare expected to learn the following: **CO1**: Basic knowledge of supramolecular chemistry **CO2**: The concepts and various terminologies in supramolecular chemistry **CO3**: Nature of supramolecular interactions **CO4**: Understanding of supramolecular concepts and design **CO5**: Knowledge of various binding hosts such as crown ethers, cryptands, spherands **CO6**: Develop skills for designing new super/supramolecules

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO SUPRAMOLECULAR CHEMISTRY** Definition and Development of Supramolecular Chemistry; What is Supramolecular Chemistry? Host–Guest Chemistry; Development; Classification of Supramolecular Host-Guest Compounds.	7
II	**TERMINOLOGIES AND CONCEPTS** Receptors, Coordination and the Lock and Key Analogy, Binding Constants; Definition and Use; Measurement of Binding Constants; Cooperativity and the Chelate Effect; Preorganisation and Complementarity; Thermodynamic and Kinetic Selectivity, and Discrimination.	8
III	**NATURE OF SUPRAMOLECULAR INTERACTIONS WITH EXAMPLES** Ion–ion Interactions; Ion–Dipole Interactions; Dipole–Dipole Interactions; Hydrogen Bonding; Cation–π Interactions; Anion-π Interactions; π–π Interactions; Van der Waals Forces and Crystal Close Packing; Closed Shell Interactions. Hydrophobic Effects, Solvation.	7
IV	**SUPRAMOLECULAR CONCEPTS AND DESIGN** Host Design; Informed and Emergent Complex Matter; Nanochemistry. Supramolecular Cation Coordination Chemistry; Concepts in Coordination Chemistry; EDTA – a Classical Supramolecular Host; Crown ethers; Cryptands; Spherands.	8

Suggested Readings:

1. J. W. Steed, J. L. Atwood, Supramolecular Chemistry, 2nd Edition. *Wiley*, 2009.
2. J. W. Steed, Supramolecular Chemistry: From Molecules to Nanomaterials, 8 Volume 7th Edition. *John Wiley & Sons*, 2012.
3. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives. *Wiley*, 2006.

Course No: CH-49	Course Name: Introduction to Nanomaterials							Course Code: SBS CH 010307 DCE 2002
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week:** 02	**Total Hrs.:** 30
Total Evaluation Marks:50 **CIE:** **15** Marks **TEE:** **35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic understanding of materials, characterization techniques, surface area and dimensionality.						
Course Objectives	*This course is designed to give exposure of nanomaterials and chemistry of it to the fresh postgraduate students. Many important nanomaterials such as graphene, carbon nanotubes, nanorods etc., their classification, synthesis, characterization and applications would be introduced to the students.*							
Course Outcomes:	After completing this course, students are expected to learn the following: **CO1**: Basic knowledge of nanomaterials **CO2**: Classification of nanomaterials in terms of dimensionality **CO3**: Various synthetic process of nanomaterials with emphasis on gas phase synthesis **CO4**: Characterization methods of nanomaterials **CO5**: Preliminary knowledge of nanotubes, nanorods and nanoplates **CO6**: Exposure of wonder materials such as graphene and carbon nanotubes							

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** An Introduction to Nanomaterials with Historical Perspectives. Nanomaterials and Nanocomposites. Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials - zero dimensional (0D), one dimensional (1D) and two dimensional (2D) nanomaterials.	6
II	**SYNTHESIS OF NANOMATERIALS** Top-Down and Bottom-Up Approach of Synthesis of Nanomaterials. Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes. Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.	8
III	**CHARACTERIZATION OF NANOMATERIALS** Characterization of Nanomaterials: Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.	8
IV	**NANOTUBES, NANORODS, AND NANOPLATES** Introduction of Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Carbon Nanotubes and Graphene, Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.	8

Suggested Readings:

1. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Edition. *Wiley-VCH*, 2013.
2. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials. *World Scientific*, 2013.

<table>
<tr><td>Course No:
CH-50</td><td colspan="2">Course Name:
Molecular Magnetism</td><td colspan="6">Course Code:
SBS CH 010308 DCE 2002</td></tr>
<tr><td>Batch:
2022
onwards</td><td>Programme:

M.Sc. Chemistry</td><td>Semester:

III</td><td>L

2</td><td>T

0</td><td>P

0</td><td>Credit

2</td><td colspan="2">Contact Hrs. per Week: 02
Total Hrs.: 30</td></tr>
<tr><td colspan="2">Total Evaluation Marks:50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 2 Hrs.

Pre-requisite of course: To provide the basic knowledge of molecular magnetism.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide the basic knowledge of origin of magnetism and molecular magnetism. At the end of this course, students will learn about the basic concept of magnetism, magnetic interaction, spin transition and magnetic exchange.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Origin of magnetism
CO2: Scope of molecular magnetism
CO3: Effective magnetic moment
CO4: Spin transition
CO5: Quantum tunneling
CO6: Single molecule magnets</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC CONCEPTS OF MAGNETISATION** Origin of magnetism, magnetic susceptibility, measurement of magnetic susceptibility: Gouy method, induction method, superconducting quantum interference device magnetometer, Evans method, zero-field cooled measurements, field scan, reduced magnetization, hysteresis, AC susceptibility, classification of magnetic behaviour: diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds.	7
II	**MAGNETIC INTERACTION** Classical *vs*. quantum model, Curie Law, Curie-Weiss Law, spin-orbit coupling, magnetically non-equivalent sites in the unit cell, solute-solvent interaction, solute-solute interaction configurational equilibrium.	8
III	**SPIN TRANSITION** Van Vleck equation, magnetic anisotropy, low spin high spin transition, mechanism of spin transition, spin cooperativity, molecular electronics, intermediate spin and spin-admixed states.	7

IV	**MAGNETIC EXCHANGE** Magnetic exchange, Bleany-Bowers equation, mechanism of exchange coupling, spin hamiltonian, magnetic interaction in oligonuclear complexes, magneto-structural correlations, quantum tunneling of magnetization, single molecule magnets.	8

Suggested Readings:

1. J. M. D. Corey, Magnetism and Magnetic Materials. *Cambridge University Press*, UK, 2010.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4^{th}Edition. *Pearson Education*, 2006.
3. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets. *Oxford University Press*, *Oxford,* 2006.
4. O. Kahn, Molecular Magnetism*, VCH Publishers, Inc.*, *Orsay, France*, 1993.

DISCIPLINE CENTRIC SKILL-BASED COURSES (DCSC)

<table>
<tr><td colspan="1">Course No:
CH-51</td><td colspan="3">Course Name:
Computational Chemistry</td><td colspan="4">Course Code:
SBS CH 010201 DCS 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: To provide the basic knowledge of computational Chemistry. Basic understanding of ab-initio methods, DFT, basis sets and potential energy map.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide the basic knowledge of various parameters and software involved in computational Chemistry and its application towards understanding the stability of molecules and proposing its reaction mechanism.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of computational chemistry
CO2: Scope of computational chemistry
CO3: Computational methods
CO4: Use of computational software and of polyatomic molecules
CO5: Skills for analyzing stability of molecules and visualization of transition states
CO6: Skills for proposing new molecules</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO COMPUTATIONAL CHEMISTRY** Scope of computational chemistry, Born-Oppenheimer approximation, Hartree-Fock theory, restricted HF calculations; open shell systems, ROHF and UHF calculations, HF limit and electron correlation, semi empirical methods.	7
II	**DENSITY FUNCTIONAL THEORY** Electron density, exchange-correlation functional, local Density approximation, generalized gradient approximation, hybrid density functional methods, self-Interaction corrections.	8
III	**BASIS SETS** Definition of basis sets, Slater and Gaussian type orbitals, minimal, double-zeta, split-valence, core-valence, Pople style basis Sets, polarization and diffuse functions, determination of basis functions, pseudopotentials or effective core potentials, choice of basis bets.	7
IV	**BASIC CONCEPTS OF POTENTIAL ENERGY SURFACES** Z-matrix construction, Stationary Points, geometry optimization, local and global minima, and transition state theory. Computations of single point energy, optimizations and transition states of polyatomic molecules, intrinsic reaction coordinate analysis.	8

Suggested Readings:

1. J. B. Foresman and A. Frisch, Exploring Chemistry with Electronic Structure Methods, 2ndEdition.*Gaussian Inc.*, 2015.
2. F. Jensen, Introduction to Computational Chemistry, *John Wiley & Sons*, 2007
3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2ndEdition.*John Wiley & Sons Ltd*, 2004.
4. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2ndEdition.*John Wiley & Sons Ltd*, 2002.
5. D. A. McQuarrie, Physical Chemistry: A molecular Approach, 1stEdition.*University Science Books*, 1997.

<table>
<tr><td colspan="1">Course No:
CH-52</td><td colspan="4">Course Name:
Analytical Techniques in Chemistry</td><td colspan="4">Course Code:
SBS CH 010202 DCS 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
M.Sc. Chemistry</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="2">Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students with a basic understanding of analytical chemistry, classical and modern analytical techniques. This course will strengthen the fundamentals of analytical chemistry, especially thermogravimetric, imaging and impedance spectroscopy techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of analytical chemistry.
CO2: Use of thermogravimetric, imaging and polarization techniques in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important analytical methods.
CO5: Development of alternate analytical methods.
CO6: Use of advanced and recent techniques in analytical chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">THERMOGRAVIMETRIC ANALYSIS (TGA/DTA/DSC)
Principle, instrumentation of TGA, DTA, and DSC. Effect of heat on Materials, Chemical decomposition and T. G. Curves, Analysis of T.G. curve to show nature decomposition reactions, the product and qualities of compounds expelled, T.G. in controlled atmosphere, applications.</td><td>8</td></tr>
<tr><td>II</td><td colspan="7">ELECTROCHEMICAL ANALYSIS
Analysis of Metal, Alloys, Soil and Fertilizers by using electrochemical techniques like cyclic voltammetry, chronoamperometry, Pulse voltammetry. Theory, principle, working and application of cyclic voltammetry, chronoamperometry, Pulse voltammetry. Use of chemical and biosensors in environmental pollutant detection.</td><td>7</td></tr>
<tr><td>III</td><td colspan="7">IMAGING TECHNIQUES
An introduction to microscopy, the transmission and scanning electron microscope, electron optics, TEM specimen preparation and imaging system, dynamics of scattering, operating principle of SEM, penetration of electron in solids, SEM operating conditions and specimen preparation, electron beam lithography.</td><td>8</td></tr>
<tr><td>IV</td><td colspan="7">ELECTROCHEMICAL POLARIZATION AND IMPEDANCE SPECTROSCOPY</td><td>7</td></tr>
</table>

	Anodic and cathodic polarization, Tafel plots, anodic and cathodic Tafel slopes, Corrosion rate from corrosion current density, Open circuit potential, Impedance spectroscopy, Nyquesi plots, Bode plots.	

Suggested Readings:

1. S. L. Chopra and J. S. Kanwar, Analytical Agriculture Chemistry, *Kalyani publishers,* 2008.
2. S. M. Khopkar, Concepts in Analytical Chemistry, 2nd Edition. New Age International Pub.2004.
3. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Instrumental methods of analysis, 7th Edition. *United States*, 1988.
4. D. A. Skoog and D. M. West, Principles of instrumental analysis, 2nd Edition. *Saunders College*, Philadelphia, 1980.
5. F. D. Snell and F. M. Biffen, Commercial Methods of Analysis, Tata McGraw Hill Book Company, New York, 1944.

Course No: CH-53	**Course Name:** Process Development of Active Pharmaceutical Ingredients				**Course Code:** SBS CH 010403 DCS 2002		
Batch: 2022 onwards	**Programme:** M.Sc. Chemistry	**Semester:** IV	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week:** **02** **Total Hrs.:** **30**
Total Evaluation Marks:50 **CIE:** **15** Marks **TEE:** **35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Understanding of general principles of chemistry and spectroscopic techniques.					
Course Objectives	*To provide the knowledge of Process Development of Active Pharmaceutical Ingredients to the students*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of active pharmaceutical ingredients **CO2**: Understand the process flow diagram and various process parameters **CO3:** Important features associated with process development of APIs **CO4**: Skills to develop technology for APIs and intermediates from lab scale to commercial batch **CO5**: understanding of GLP, GMP and safety in API industry **CO6**: Ability to understand various issues related to regulatory affairs						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**PHARMACEUTICAL INDUSTRY AND ACTIVE PHARMACEUTICAL INGREDIENTS(APIS)** Pharmaceutical industries: Past and present; Introduction and Importance of active pharmaceutical ingredients, bulk drugs and their intermediates, Import and Export of APIs Scale-up approach of APIs: process research and development, optimization, maximization of percentage yield of the product, in-process control techniques.	8
II	**CHEMICAL TECHNOLOGY OF SELECTED APIS** Case studies with special emphasis on various factors for selection of routes: availability of raw materials and intermediates, process control parameters, pollution control procedures, polymorphs, safety issues, productivity etc.	7
III	**PROCESS TECHNOLOGY and REGULATORY PROFILE** Overview of plant layout, plant design, utilities and process flow sheets, Raw material consumption and costing, Overview of GLP, GMP and safety in API industry, Overview of Quality Assurance and Regulatory Affairs	8
IV	**STABILITY OF PRODUCTS** Drug substance – criteria, storage conditions, long term testing accelerated testing, frequency, evaluation, labeling; Drug product- selection of batches criteria, specification, conditions of storage and testing.	7

Suggested Readings:

1. N. G. Anderson, Practical Process Research and Development, 2^{nd} Edition. *Academic Press, Elsevier*, 2012.
2. P. J. Harrington, Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up, *Wiley*, 2011.
3. D. Lednicer, Strategies for Organic Drug Synthesis and Design, 2^{nd} Edition, *Wiley*, 2008.
4. D. J. Pisano, D. S. Mantus, FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics 2^{nd} Edition. *CRC Press*, 2008
5. K. Gadamasetti, Process Chemistry in Pharmaceutical Industry, Volume-I & II, *Taylor and Francis*, 1999.

Course No:	Course Name:	Course Code:
CH-54	Chemistry of Industrially Important Products	SBS CH 010404 DCS 2002

Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week:** 02
2022 onwards	M.Sc. Chemistry	IV	2	0	0	2	**Total Hrs.: 30**

Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Understanding of general principles of chemistry and spectroscopic techniques in addition to synthetic aspects.
Course Objectives	*To provide the knowledge of Chemistry of Industrially Important Products to the students*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Overview of industrially important products **CO2**: Various process parameters associated with dyes, pigments, petrochemicals, blends, additives and polymers **CO3:** Important features associated with process development of industrially important compounds **CO4**: Skills to develop technology for of industrially important compounds **CO5**: Understanding of agrochemicals and polymers used in textile industries **CO6**: Ability to understand various issues related to petrochemicals and dyes

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**DYES AND PIGMENTS** Introduction and classification of dyes, color & constitution, different types of chromophores. Fluorescence and phosphorescence, dye intermediates, Developments of acid and basic dyes. Applications of different dyes and challenges associated with them. Chemistry and applications of optical brightening agents and pigments.	8
II	**PETROCHEMICALS** Crude oil and natural gas, refinery operations, energy consumption, lower olefins and acetylenes, cracking processes, synthesis gas, ammonia and methanol production, acetic acid and acetic anhydride production, C_1 products: Formic acid, hydrogen cyanide, chloromethanes, C_2 products: ethanol, acetaldehyde, ethylene oxide	7
III	**PROCESS TECHNOLOGY OF POLYMERS/FABRICS** Chemistry and Technology of chemical processing of polyester, nylon and acrylics. Dyeing machines for dyeing fiber, yarn and fabric. Mass coloration. Coloration of polypropylene	8

IV	**BLENDS, ADDITIVES AND AGROCHEMICALS** Blends, antioxidants, UV stabilizers, antistatic agents, peroxides, lubricants, fire retardants, heat stabilizers, plasticizers. Agricultural Chemicals: Fertilizers, insecticides, herbicides, fungicides.	7

Suggested Readings:

1. A. Heaton, An introduction to Industrial Chemistry, 3rd Edition, *Springer Science,* 2013.
2. K. Venkataraman, The Chemistry of Synthetic Dyes, *CBS*, 2010.
3. J. A. Tyrell, Fundamental of Industrial Chemistry, *Wiley*, 2005.
4. K. Hunger, Industrial Dyes: Chemistry, Properties, Applications, *Wiley*, 2002.
5. K. V. Datye and A. A. Vaidya, Chemical Processing of Synthetic Fibers and Blends, *Wiley*, 1984.

DISSERTATION
(Research Project)

<table>
<tr><td colspan="2">Course No:
CH-55A</td><td colspan="5">Course Name:
Dissertation-I</td><td colspan="2">Course Code:
SBS CH 010327 DCS 001408</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 14</td></tr>
<tr><td>0</td><td>0</td><td>14</td><td>8</td><td colspan="2">Total Hrs.: 220</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 200

CIE: 66 Marks

TEE: 134 Marks</td><td colspan="7">Examination Duration: External Viva-Voce</td></tr>
<tr><td colspan="7">Pre-requisite of course: None</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The aim of the dissertation project work is to familiarize the students with advanced research.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Overview of handling research projects
CO2: Develop skills in planning and setting-up experiments
CO3: Handling of various instruments
CO4: Research presentation skills
CO5: Ability to understand various issues related to research
CO6: Skills in writing research reports</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td colspan="2">Contact Hrs.</td></tr>
<tr><td>I-IV</td><td colspan="6">This course applies to students who opt to carry out their dissertation work in Central University of Haryana. The topic for the project work is to be decided by the supervisor/guide concerned. The project report is to be evaluated by a committee constituted by the Head, Department of Chemistry, School of Basic Sciences having at least one external member.</td><td colspan="2">220</td></tr>
</table>

<table>
<tr><td colspan="2">Course No:
CH-55B</td><td colspan="4">Course Name:
Dissertation-II</td><td colspan="3">Course Code:
SBS CH 010428 DCS 001408</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 14</td></tr>
<tr><td>0</td><td>0</td><td>14</td><td>8</td><td colspan="2">Total Hrs.: 220</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 200

CIE: 66 Marks

TEE: 134 Marks</td><td colspan="6">Examination Duration: External Viva-Voce</td></tr>
<tr><td colspan="6">Pre-requisite of course: None</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The aim of the dissertation project work is to familiarize the students with advanced research.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Overview of handling research projects
CO2: Develop skills in planning and setting-up experiments
CO3: Handling of various instruments
CO4: Research presentation skills
CO5: Ability to understand various issues related to research
CO6: Skills in writing research reports</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td colspan="2">Contact Hrs.</td></tr>
<tr><td>I-IV</td><td colspan="6">This course applies to students who opt to carry out their dissertation work in Central University of Haryana. The topic for the project work is to be decided by the supervisor/guide concerned. The project report is to be evaluated by a committee constituted by the Head, Department of Chemistry, School of Basic Sciences having at least one external member.</td><td colspan="2">220</td></tr>
</table>

GENERIC ELECTIVE COURSES

ELECTIVE COURSE OFFERED BY THE DEPARTMENT TO STUDENTS OF OTHER DEPARTMENTS

Course No: CH-58	**Course Name:** Chemistry for Biologists				**Course Code:** SBS CH 010101 GE 4004		
Batch: 2022 onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** I	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week:** 04 **Total Hrs.:** 60

Total Evaluation Marks:100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** None

Course Objectives	*To provide an opportunity to learn some basic concepts of chemistry important for biologists.* *To provide the knowledge of UV-vis., IR and* ^{1}*H-NMR spectroscopy*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of some important concepts of chemistry **CO2**: Understanding of formulae writing and stereochemistry of organic compounds **CO3:** Important aspects associated with other branches of science **CO4**: Skills to interpret data of organic compounds using advanced spectral techniques **CO5**: Ability to communicate about chemical sciences across the fields **CO6**: Ability to analyse, design and solve problems

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

iii) P.G. Students from other departments may opt this course.

Unit No.	Contents	Contact Hrs.
I	**SOME BASIC TERMS AND CONCEPTS** Mole concept and Stoichiometry. Solution and different methods of expressing the concentration of a solution. Chemical bonds: Ionic, covalent, coordinate and metallic bonds. Shapes of the molecules, Polarized chemical bonds and polarity in the molecules. Intermolecular forces: Dispersion, dipole-dipole, hydrogen bonds, ion-dipole forces and their effect on the properties of the compounds. Biological implications of hydrogen bonding. Problems based on given topics.	15
II	**STEREOCHEMISTRY** Isomerism: Introduction, Formula writing, Structural and stereo isomerism, Conformations: analysis of ethane, *n*-butane, cyclohexane and its derivatives, Configurational isomerism, Geometrical and optical isomerism. Symmetry and chirality in the molecules having one or more than one chiral center, R & S, D & L, threo and erythro nomenclature, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective reactions. Problems based on given topics.	15

III	**CONCEPTS OF PHYSICAL CHEMISTRY** Thermodynamics: Change in Internal energy, enthalpy, free energy and entropy; Endothermic and exothermic processes, Exergonic and endergonic processes, Coupled biological processes, Chemical Kinetics: Reaction rate and rate constant, Catalysts and catalysis, Enzymes as catalysts, Enzyme inhibition. Chemical equilibrium: Equilibrium, equilibrium constant, Le Châtelier's principle and factors affecting the principle, Aqueous Equilibria: Introduction, importance in biology, pH and pH control, Buffers and their importance.	15
IV	**SPECTROSCOPIC TECHNIQUES** Ultraviolet and visible (UV-vis) spectroscopy: Introduction, Principle and selection rules of UV phenomenon, Various electronic transitions, Beer-Lambert law, presentation of spectrum, effect of solvents on electronic transitions, ultraviolet bands for carbonyl compounds and unsaturated carbonyl compounds. Fieser-Woodward rules for conjugated dienes. Infrared Spectroscopy: Introduction, Principle and selection rules of IR spectroscopy, Hookes law, Characteristic vibrational frequencies of organic compounds. Overtones, combination bands and Fermi resonance. Factors affecting the vibrational frequencies. ^{1}H NMR: Principle, nuclear spin states, nuclear magnetic moments, mechanism of resonance, chemical shifts, diamagnetic shielding, magnetic anisotropy, spin-spin splitting, coupling constant, ^{1}H NMR spectra of various simple organic compounds.	15

Suggested Readings:

1. B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry,47th Edition. *Vishal Publishing Co.,* 2017.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, 33rd Edition. *Vishal Publishing Co.,* 2017.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Spectroscopy, 5th Edition. *Cengage Learning India Private Limited,* 2015.
4. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, *New Age International Private Limited*, 2015.
5. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd*., 2015.
6. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
7. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
8. Morrison, Boyd and Bhattcharjee, Organic Chemistry, 7th Edition, *Pearson*, 2010.
9. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A., *Springer*, 2007.
10. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edition, *New Age International*, 2005.
11. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 1997.

<table>
<tr><td rowspan="1">Course No:
CH-59</td><td colspan="4">Course Name:
Chemistry of Materials</td><td colspan="4">Course Code:
SBS CH 010102 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:
P.G. (Generic Elective Course)</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: To provide basic nanomaterials and photophysical phenomena</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To give a very basic understanding of Chemistry of nanomaterials, porous materials and some photophysical phenomena with focus on energy and environment.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of nanomaterials
CO2: To understand the dramatic changes in properties that occurs by reducing the size
CO3: Characterization of nanomaterials
CO4: To impart knowledge on how to perform the synthesis of such small sizes and shapes of materials
CO5: Knowledge of fundamental of photophysical phenomena
CO6: Application of nanomaterials and photophysical phenomenon</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**NANOMATERIALS** An Introduction, Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials-zero dimensional (0D)-one dimensional (1D)-two dimensional (2D) nanomaterials. Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes. Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.	15
II	**CHARACTERIZATION OF NANOMATERIALS** Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy. Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Graphene and Carbon Nanotubes. Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.	15
III	**HYBRID MATERIALS** Coordination Polymers, Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Charaterization: X-ray diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery.	15

IV	**PHOTOPHYSICAL PHENOMENA** Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence, quantum yield, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, types of photophysical pathways, radiationless transitions, fluorescence emission, phosphorescence emission, Fluorescence quenching, chemiluminescence, photochemical reactions.	15

Suggested Readings:

1. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Edition. *Wiley-VCH*, 2013.
2. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials. *World Scientific*, 2013.
3. S. R. Batten, S. M. Neville and D. R. Turner, Coordination Polymers: Design, Analysis and Application. *RSC Publishing*, 2009.
4. M.-C. Hong and L. Chen, design and Construction of Coordination Polymers. *Wiley*, 2009.
5. S. Kaskel, The Chemistry of Metal-Organic Frameworks, Vol. 1, *Wiley-VCH*, 2016.
6. L. R. Macgillivray, Metal-Organic Frameworks: Design and Applications, *Wiley*, 2010.
7. W. D. Jr. Callister and D. G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, *John Wiley and Sons*, 2012.
8. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rdEdition. *New Age International (P) Ltd.*, 2014.

<table>
<tr><td colspan="1">Course No:
CH-60</td><td colspan="3">Course Name:
Medicinal Chemistry</td><td colspan="5">Course Code:
SBS CH 010203 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:

P.G. (Generic Elective Course)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: To provide basics of medicinal chemistry</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course will provide a basic understanding and fundamentals of Medicinal Chemistry, drug-target actions, process of development of new drugs and regulatory processes of drug approval, intellectual property and drug abuse and misuse.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following.
CO1: General overview about drugs and their function
CO2: Idea of the various steps in drug discovery and development
CO3: Fundamental understanding of how drug-target interactions happen
CO4: Basic understanding of chemical principles involved in pharmacodynamics
CO5: Classification and uses of various drugs
CO6: A broad idea of drug manufacture, administration and drug abuse</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.
iii) P.G. Students from other departments may opt this course.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">FUNDAMENTALS
Historical development of systems of medicine, Basic chemical and biochemical principles, Key definitions, drug, target, receptors, enzymes, common drugs and their classification, anti-inflammatory drugs, antihistamines, antacids, antibiotics, narcotics, antivirals, and antineoplastics.</td><td>15</td></tr>
<tr><td>II</td><td colspan="7">DRUG ACTION
Chemistry of drug-target interactions, bioavailability, drug absorption, distribution, metabolism, excretion (ADME), pharmacokinetics and pharmacodynamics, toxicity, side effects, lipophilicity and hydrophilicity, blood-brain barrier and its significance, routes of drug administration</td><td>15</td></tr>
</table>

III	**DRUG DESIGN AND SYNTHESIS** Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), isosterism, bio-isosterism, important chemical principles behind design of drugs, natural products and their uses, chemical synthesis of drugs, drug formulation, drug delivery, photodynamic therapy.	15
IV	**DRUGS AND SOCIETY** Regulatory processes for drug approval, regulatory agencies, intellectual property, patents, drug misuse, drug abuse, abuse of antibiotics, fraud practices in treatment, historically important drugs and vaccines.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rdEdition. *Academic Press*, 2014.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
3. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2ndEdition. *Pearson*, 2012.
4. Ed. Robert F. Dorge, Wilson and Gisvold'sTextBook of Organic Medicinal and Pharmaceutical Chemistry, 12thEdition, 2010.
5. Ed. M. E. Wolff, Burger's Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Edition. *John Wiley*, 2010.
6. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

<table>
<tr><td>Course No:
CH-61</td><td colspan="5">Course Name:
Drug, Design and Discovery</td><td colspan="3">Course Code:
SBS CH 010304 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:
P.G. (Generic Elective Course)</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="8">This course will provide a basic understanding and fundamentals towards drug discovery and development process.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: General idea about modern medicine and medicinal chemistry
CO2: The process of drug discovery and development
CO3: Fundamental understanding of how drug-target interactions happen
CO4: Basic understanding of chemical principles involved in pharmacodynamics
CO5: Classification and uses of various drugs
CO6: A broad idea of drug manufacture, administration and drug abuse</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.
iii) P.G. Students from other departments may opt this course.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** ***History of drug discovery and targets***: Introduction, Stages of drug discovery, lead discovery, Recent trends in drug discovery. Validation and diversity of drug targets ***Biological drug targets***: Drug target identification, Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes, Biopharmaceutical therapies, , Hit to lead, Clinical biomarkers.	15
II	**DRUG DESIGN** ***Prodrug design:*** Basic concept, Carrier linked prodrugs/Bioprecursors, prodrugs of functional group, prodrugs to improve patient acceptability, Drug solubility, drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug design and practical consideration of prodrug design. ***Combating drug resistance***: Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, genetic principles of drug resistance. ***Analog Design***: Introduction, classical & non-classical, bioisosteric replacement strategies, rigid analogs, alteration of chain branching, changes in ring size, ring position isomers, design of stereo isomers and geometric isomers, fragments of a lead molecule, variation in inter atomic distance	15

III	**ANTIBIOTICS AND CARDIOVASCULAR DRUGS** Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxycillin, cephalosporin, ciprofloxacin. Introductory idea of tetracycline and streptomycin. Introduction and general mode of action. Synthesis of ditiazem, verapamil, methyldopa and atenolol.	15
IV	**LOCAL ANTIINFECTIVE DRUGS AND PSYCHOACTIVE DRUGS** Introduction and general mode of action. Synthesis of furazolidone, naldixic acid, dapsone, isoniazid, ethambutol, gluconazole, chloroquin and primaquin. Introduction, neurotransmitters, CNS depressants, general anaesthgetics, mode of action of hypnotics,sedatives, anti-anxiety drugs, benzodiazopines, buspirone. Antipsychotic drugs–theneuroleptics, antidepressants, butyrophenones. Synthesis of diazepam, alprazolam,phenyltoin and glutethimide.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Edition. *Academic Press*, 2014.
2. D. M. Brahmankar and S. B. Jaiswal, Biopharmaceutics and Pharmacokinetics, 2ndEdition. *Vallabh Prakashan,* New Delhi, 2014.
3. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
4. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2ndEdition. *Pearson*, 2012.
5. Ed. Robert F. Dorge, Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, 2010.
6. Ed. M. E. Wolff, Burger's Medicinal Chemistry and Drug Discovery, Volume 1, 7th Edition. *John Wiley*, 2010.
7. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

Course No: CH-62	Course Name: Magneto Nuclear Chemistry	Course Code: SBS CH 010405 GE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 02
2022 onwards	P.G. (Generic Elective Course)	IV	2	0	0	2	Total Hrs.: 30

Total Evaluation Marks:50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** To provide the basic knowledge of magnetism and nuclear chemistry.
Course Objectives	*To provide the basic knowledge of origin of magnetism and* nuclear chemistry. *At the end of this course, students will learn about the basic concept of magnetism, magnetic interaction, spin transition and magnetic exchange.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic theory of magnetism **CO2**: Knowledge of exchange interaction **CO3**: To understand orbital contribution **CO4**: Basic understanding of nuclear structure **CO5**: To understand artificial radioactivity and chelation therapy **CO6**: Scope of magnetism and nuclear chemistry

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC CONCEPTS OF MAGNETISM** Definition, Origin of magnetism, classification of magnetic behaviour; diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds, magnetic interactions, spin crossover, spin-orbit coupling, Curie law, Curie-Weiss law	7
II	**MAGNETIC INTERACTION** Mechanism of exchange interaction, reduced magnetization, magnetic hysteresis, calculation of magnetic moment, orbital contribution to the magnetic moment, anomalous magnetic moments, magnetic susceptibility.	8
III	**RADIOACTIVITY** Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Measurement of radioactivity, group displacement law, radioactive disintegration series, rate of disintegration, half-life, average life of radioactive elements, unit of radioactivity, nuclear decay, determination of decay constants, decay rates, types of nuclear decay.	7

IV	**ARTIFICIAL RADIOACTIVITY AND APPLICATIONS OF NUCLEAR CHEMISTRY** Discovery of artificial radioactivity, isotopes used in medicines, radiocarbon dating, age determination, effects of radiation on life, applications of tracer element in medical, agriculture and analytical fields, biological effects of radiation, radiation protections, chelation therapy.	8

Suggested Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rdEdition.*Willey*, 2013.
2. J. M. D. Coey, Magnetism and Magnetic Materials, *Cambridge University Press*, UK, 2010.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.
4. W. D. Loveland, D. Morrissey and G. T. Seaborg, Modern Nuclear Chemistry, *John Wiley & Sons*, 2006.
5. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, *Oxford University Press*, Oxford, 2006.
6. C. E. Housecroft and A. G. Sharpe; *Inorganic Chemistry*, 2ndEdition.*Pearson*, 2005.
7. O. Kahn, Molecular Magnetism, *VCH Publishers, Inc.*, Orsay, France, 1993.
8. H. J. Arnikar, Essentials of Nuclear Chemistry, *Wiley Eastern*, 1988.

SWACHH BHARAT INTERNSHIP PROGRAMME

<table>
<tr><td colspan="2">Course No:
CH-56</td><td colspan="5">Course Name:
Activities at Department and University Level*</td><td colspan="2">Course Code:
SBS CH 010105 DCS 0042</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:

M.Sc. Chemistry</td><td rowspan="2">Semester:

I to IV</td><td>L</td><td>T</td><td>A</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 7</td></tr>
<tr><td>0</td><td>0</td><td>7</td><td>2</td><td colspan="2">Total Hrs.: 100</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: Evaluation will be done at departmental level by giving the remarks as Excellent/Good/Satisfactory/Poor</td><td colspan="7">Examination Duration: NA</td></tr>
<tr><td colspan="7">Pre-requisite of course: None</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The main objective of this course is to make the students aware about the importance of cleanliness for social development.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Learn about the importance of cleanliness
CO2: Develop skills in finding and solving sanitation related problems
CO3: Motivating others not to litter
CO4: Motivating others not to use plastic bags
CO5: To manage and implement campaigns and demonstrate sanitation advice in nearby villages.
CO6: Skill to train others</td></tr>
</table>

COURSE SYLLABUS

<table>
<tr><th>Unit No.</th><th>Contents</th><th>Contact Hrs.</th></tr>
<tr><td>I-IV</td><td>This course is applicable to all students to carry out various activities associated with cleanliness and recycling of the waste materials at departmental and university level in line with Swachh Bharat Abhiyan that may include:
● To conduct outreach programs for creating awareness on Swachh Bharat in association with NCC or NSS or women cell etc.
● To produce energy and manure using bio-wastes.
● Plantation drives to increase the green cover and conservation of old trees.
● Self-sustainable units through energy production using solar panels.
● Plastic free environment.
● Development of Green Buildings concept in the society.
● Effective Waste management and recycling.
● Rain water harvesting.
● Proper disposal of chemical waste.
● Creating awareness in the community through short films.
● Use of social media for broader community outreach.

Note: Students will submit a brief report on the activities carried out to the department for the record purpose.</td><td>100</td></tr>
</table>

A = Activity

*https://www.ugc.ac.in/pdfnews/8118809_UGC-Letter-reg-Swachcha-Bharat-Abhiyan-.pdf

9. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning
- Hands on training
- Self study analysis
- Report writing

10. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;

- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, may be adopted

11. ASSESSMENT AND EVALUATION

Overall assessment will be made as per CUH PG ordinances

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired if required
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. KEYWORDS

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes

- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. REFERENCES

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. APPENDICES

Curricular Reforms — Extracts from National Education Policy-2020

8118809_UGC-Letter-reg-Swachcha-Bharat-Abhiyan-.pdf (https://www.ugc.ac.in/pdfnews/8118809_UGC-Letter-reg-Swachcha-Bharat-Abhiyan-.pdf)

3258851_swach-bharat-swashth-bharat--guidelines-2014.pdf

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi
Of
Integrated B.Sc.-M.Sc. (Chemistry)

(For the students enrolled in 2021 only)

DEPARTMENT OF CHEMISTRY
SCHOOL OF BASIC SCIENCES

	BOS	School Board	Academic Council
Approved by :			
Approval Status :	√	√	
Approval Date :	06-09-2022	12-09-2022	

Table of Contents

VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a world-class teaching and research reputation of the department that contributes to society through its innovative, creative and scholarly approach.

Mission

To educate the students by adopting highest academic and professional standards to meet the global competency in the field of chemical sciences. To establish and maintain a high quality of support, research facilities, multidisciplinary and skill-based learning opportunities to our staff, students and researchers to orient them to world class creative and innovative minds.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in the 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills;

community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About Chemistry

Chemistry is the science of matter and its transformations. It addresses fundamental questions about the observable matter, ranging from its components, structure, properties and interconversions. As a system of knowledge, Chemistry not only explains the existence and behavior of matter around and within us, but also empowers us to manipulate the matter into new and improved forms for our use. From the ancient practices of rasayan vidya and alchemy, modern chemistry has grown over centuries into a formidable science that touches all aspects of human life. Humanity's progress in the last three centuries is pivoted on the contributions of chemistry, chemical industry and associated endeavors. The range of influence of chemistry in our life spans from essentials such as food (agrochemicals, preservatives), shelter (cement, metals, alloys, polymers) and health (drugs, cosmetics, soap, toothpaste), to advancements such as textiles (polymers, leather), beverages (flavoring and fermentation), crime fighting (forensics), weaponry (explosives), space travel (fuel) and cosmology (element detection). The list can go on endlessly. The most visible contribution of chemistry to civilization is achieved by the advancements in modern medicine that was fuelled by organic chemistry. This led to significant improvements in the living standards, extension of human average life span and fighting of dangerous diseases such as cancer and microbial infections.

Chemistry is placed centrally between the other two major branches of science, namely physics and biology. Therefore, it is often called the *central science*. It influences the developments in these two broad realms of science as much as it is influenced by the discoveries in them. The fundamental importance of chemistry and chemical industry in sustaining human civilization demands for a steady supply of trained and skilled manpower. Thus, it is unsurprising that it is an essential and integral department in higher education institutions.

Education in chemistry not only imparts the technical know-how about structure, reactions and properties of matter, but also empowers the learner to raise fundamental questions about various natural phenomena, address local issues and come up with sustainable solutions, identify areas of life where intervention of chemistry can bring about progress and imbibe and spread the spirit of free enquiry and scientific temper.

iii) About the Programme (Nature, Extent and Aims)

The integrated B.Sc.-M.Sc. Programme in Chemistry will impart advanced knowledge of basic and applied chemical sciences to the graduates. It will prepare the students for taking up challenging assignments in academia and industry and also empower them with skill and knowledge for generating employment for their own and others. The Programme introduces the students to advanced developments in chemical sciences as well as in the field of other allied sciences, by providing them multidisciplinary and interdisciplinary courses. The design of choice-based curriculum can enrich students with analytical and problem-solving capabilities. It is designed to bring out the best of the abilities of each student, allow them to sharpen the scientific temper and be abreast with the contemporary developments in the area.

The programme includes a balanced combination of *Core*, *Elective* and *Ability Enhancement* Courses. The courses are designed in such a way to cover the entire spectrum of chemical sciences from fundamentals (that will bring admitted students from various backgrounds to a common level) to most recent advancements in the field (that will make them ready to take up challenging assignments in the real world).

The integrated B.Sc.-M.Sc. Programme in Chemistry is of a five-year duration which is divided into ten semesters. The teaching and learning in the Programme will involve theory (lectures), practicals, tutorial and seminar-based classes. During the whole programme about 40 % syllabus of each course may be delivered via online mode and with a blended teaching-learning approach.

The curriculum will be taught through formal lectures with the aid of pre-made presentations, audio and video tools whenever necessary. Other teaching aids can also be used as and when required. The additional requirements like industrial visits, summer training and project work are also incorporated into the curriculum.

The Aims of the programme include

- To inculcate basic to advanced knowledge of chemical sciences among students.
- To provide higher education, disciplinary and inter/multi-disciplinary research-oriented knowledge to the students to make them lifelong learners.
- To provide a learned, skilled and creative pool of graduates who are ready to take up challenging assignments in different kinds of chemical industries, research institutions and academia.

- To mould responsible, proactive citizens who are equipped with scientific thinking and skills to address problems of their locality
- Adequate blend of theory, computation and hands-on experiments.
- Modernized lab courses – close to recent/current research.

iv) Qualification Descriptors (possible career pathways)

On successful completion of the Integrated B.Sc.-M.Sc. Chemistry Programme, students of the department are expected to be ready to take up opportunities all around the world in areas that demand skills in chemical and allied sciences. As the chemical industry is enormously vast and diverse, numerous opportunities and challenges await the graduates. The graduates are expected to satisfactorily address the professional expectations, maintain a work-life balance and lead productive and meaningful lives. Some of the possible career paths for the undergraduate and postgraduate students may be:

1. Teaching and Research in academia

2. Research scientists in pharmaceutical and other chemical and material industries

3. Research scientists in other allied sciences

4. Entrepreneurship in chemical science-based ventures

5. Administrative Assignments in various government and private agencies

6. Chemist/Scientist/Technician assignments in any of the following industries: pharmaceutical, polymers, petrochemicals, materials sciences, nanotechnology, fuels, non-conventional energy, renewable resources, agrochemicals, fermentation and processing, paints and pigments, metallurgy, packaging, cosmetics, cements, natural products, forensics, explosives, and any other various allied branches of chemistry.

2. STRUCTURE OF INTEGRATED B.Sc.-M.Sc. PROGRAMME

The Integrated B.Sc.-M.Sc. Chemistry Programme is of a *five-year* duration which is divided into ten semesters. The programme under Choice-Based Credit System (CBCS) includes a balanced combination of *Core*, *Elective* and *Ability Enhancement Courses* (Compulsory and Skill based). Distribution of the courses for undergraduate programme (for first three years) is given in **Table-1**.

The programme offers exit options to the students as per the relevant ordinances of CUH and guidelines of UGC and Ministry of Education.

After successful completion of five years (ten semesters) of the programme the candidate will be awarded with the Integrated Degree i.e. **Integrated B.Sc.-M.Sc. (Chemistry)**.

Table 1 (Credit % age of courses for first three years of the Programme)

Sr. No.	**Types of Courses**	**Nature**	**Total Credit**	**Credit % age of Courses**	**% age of Courses**
1	**Core Courses (CC)**	Compulsory Courses (CC)	84	56.75	53.85
2	**Elective Courses (EC)**	Discipline Specific Elective Courses (DSE)	24	16.21	15.38
		Generic Elective Courses (GE)	24	16.21	15.38
3	**Ability Enhancement Courses (AEC)**	Ability Enhancement Compulsory Courses (AECC)	8	5.40	7.69
		Ability Enhancement Elective (Skill Based) (SEC)	8	5.40	7.69
			148	**100**	**100**

Course Structure (Chemistry Major)

Details of courses for first three years

Courses	**Credits*** Theory+ Practical	**Credits*** Theory + Tutorial
I. Core Courses **(14 Papers)**	14×4 = 56	14×5 = 70
Core Course Practical / Tutorial* **(14 Papers)**	14×2 = 28	14×1= 14
II. Elective Courses **(8 Papers)**		
A.1. Discipline Specific Elective **(4 Papers)**	4×4 = 16	4×5 = 20
A.2. Discipline Specific Elective Practical/Tutorial* **(4 Papers)**	4×2 = 08	4×1 = 04
B.1. Generic Elective/Interdisciplinary **(4 Papers)**	4×4 = 16	4×5 = 20
B.2. Generic Elective Practical/ Tutorial* **(4 Papers)**	4×2 = 08	4×1 = 04
Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester		
III. Ability Enhancement Courses **1. Ability Enhancement Compulsory**** **(2 Papers of 4 credit each)** Environmental Science/ English/ MIL Communication/Sanskrit/Hindi	2×4 = 08	2×4 = 08
2. Ability Enhancement Elective (Skill Based) (Minimum 2) **(2 Papers of 4 credit each)**	2×4 = 08	2×4 = 08
Total credit	**148**	**148**
Institute should evolve a system/policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own. **** wherever there is a practical there will be no tutorial and vice-versa., ** University/Department may add/ delete any course as per need***		

3. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION (for first three years)

First Year

Sr. No	Course No	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester I								
1		Inorganic Chemistry-I: Atomic Structure & Chemical Bonding-I	SBS CH 020101 C 4004	CC	4	0	0	4
2		Physical Chemistry-I: States of Matter & Ionic Equilibrium	SBS CH 020102 C 4004	CC	4	0	0	4
3		Inorganic Chemistry Practical-I	SBS CH 020103 C 0042	CC	0	0	4	2
4		Physical Chemistry Practical-I	SBS CH 020104 C 0042	CC	0	0	4	2
5		From the list of courses (To be offered to other Department students)		GE*	4	0	0	4
6		From the list of courses (To be offered to other Department students)		GE*	0	0	4	2
7		From the list of courses		AECC	4	0	0	4
					Total Credit 22			
Semester II								
1		Organic Chemistry-I: Basics & Hydrocarbons	SBS CH 020201 C 4004	CC	4	0	0	4
2		Physical Chemistry-II: Thermodynamics & its Applications	SBS CH 020202 C 4004	CC	4	0	0	4
3		Organic Chemistry Practical-I	SBS CH 020203 C 0042	CC	0	0	4	2
4		Physical Chemistry Practical-II	SBS CH 020204 C 0042	CC	0	0	4	2
5		From the list of courses (To be offered to other Department students)		GE*	4	0	0	4
6		From the list of courses (To be offered to other Department students)		GE*	0	0	4	2
7		From the list of courses		AECC	4	0	0	4
					Total Credit 22			

CC = Core Course; GE = Generic Elective Course; AECC = Ability Enhancement Compulsory Course*
** The students of Integrated B.Sc. M.Sc. (Chemistry) programme will opt the GE courses offered by other departments of the University*

Second Year

Sr. No	Course No	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester III								
1		Inorganic Chemistry-II: s and p-Block Elements	SBS CH 020301 C 4004	CC	4	0	0	4
2		Organic Chemistry-II: Oxygen Containing Functional Groups	SBS CH 020302 C 4004	CC	4	0	0	4
3		Physical Chemistry-III: Phase Equilibria & Chemical Kinetics	SBS CH 020303 C 4004	CC	4	0	0	4
4		Inorganic Chemistry Practical-II	SBS CH 020304 C 0042	CC	0	0	4	2
5		Organic Chemistry Practical-II	SBS CH 020305 C 0042	CC	0	0	4	2
6		Physical Chemistry Practical-III	SBS CH 020306 C 0042	CC	0	0	4	2
7		From the list of courses (To be offered to other Department students)		GE*	4	0	0	4
8		From the list of courses (To be offered to other Department students)		GE*	0	0	4	2
9		From the list of courses		SEC	4	0	0	4
					Total Credit 28			
Semester IV								
1		Inorganic Chemistry-III: Coordination Chemistry	SBS CH 020401 C 4004	CC	4	0	0	4
2		Organic Chemistry-III: Heterocyclic Chemistry	SBS CH 020402 C 4004	CC	4	0	0	4
3		Physical Chemistry-IV: Electrochemistry	SBS CH 020403 C 4004	CC	4	0	0	4
4		Inorganic Chemistry Practical-III	SBS CH 020404 C 0042	CC	0	0	4	2
5		Organic Chemistry Practical-III	SBS CH 020405 C 0042	CC	0	0	4	2
6		Physical Chemistry Practical-IV	SBS CH 020406 C 0042	CC	0	0	4	2
7		From the list of courses (To be offered to other Department students)		GE*	4	0	0	4
8		From the list of courses (To be offered to other Department students)		GE*	0	0	4	2
9		From the list of courses		SEC	4	0	0	4
					Total Credit 28			

CC = Core Course; GE = Generic Elective Course; SEC = Skill Enhancement Course. (Students may choose any one from the given list). *The students of Integrated B.Sc. M.Sc. (Chemistry) programme will opt the GE courses offered by other departments of the University.*

Third Year

Sr. No	Course No	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester V								
1		Organic Chemistry-IV: Biomolecules	SBS CH 020501 C 4004	CC	4	0	0	4
2		Physical Chemistry-V: Quantum Chemistry & Spectroscopy	SBS CH 020502 C 4004	CC	4	0	0	4
3		Organic Chemistry Practical-IV	SBS CH 020504 C 0042	CC	0	0	4	2
4		Physical Chemistry Practical-V	SBS CH 020505 C 0042	CC	0	0	4	2
5		Discipline Specific Elective -1		DSE	4	0	0	4
6		Discipline Specific Elective -2		DSE	4	0	0	4
7		Discipline Specific Elective Practical-1		DSE	0	0	4	2
8		Discipline Specific Elective Practical-2		DSE	0	0	4	2
					Total Credit 24			
Semester VI								
1		Inorganic Chemistry-IV:	SBS CH 020601 C 4004	CC	4	0	0	4
2		Organic Chemistry-V:	SBS CH 020602 C 4004	CC	4	0	0	4
3		Inorganic Chemistry Practical-IV:	SBS CH 020604 C 0042	CC	0	0	4	2
4		Organic Chemistry Practical-V:	SBS CH 020605 C 0042	CC	0	0	4	2
5		Discipline Specific Elective -3		DSE	4	0	0	4
6		Discipline Specific Elective -4		DSE	4	0	0	4
7		Discipline Specific Elective Practical-3		DSE	0	0	4	2
8		Discipline Specific Elective Practical-4		DSE	0	0	4	2
					Total Credit 24			
CC = Core Course; DSE = Discipline Specific Elective Course (Students may choose any one from the given list).								

Total Credit (for 03 Years) = 148

NOTE:

i. **MOOC courses (SWAYAM) having similarity more than 75% with the core course may be offered to the students. For elective courses (whatever nomenclature may be used), the students may opt from the MOOC courses provided these courses are not in the list of core course (SWAYAM) keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.**

ii. **Scheme and Syllabi for Fourth and Fifth Year (M.Sc.) are yet to be finalized.**

LIST of COURSES

Core Papers (C): (Credit: 06 each) (1 period/week for tutorials or 4 periods/week for practical)

1. Inorganic Chemistry I: Atomic Structure & Chemical Bonding (4 + 4)
2. Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 4)
3. Organic Chemistry I: Basics and Hydrocarbons (4 + 4)
4. Physical Chemistry II: Chemical Thermodynamics and its Applications (4 + 4)
5. Inorganic Chemistry II: s- and p-block Elements (4 + 4)
6. Organic Chemistry II: Oxygen Containing Functional Groups (4 + 4)
7. Physical Chemistry III: Phase Equilibria and Chemical Kinetics (4 + 4)
8. Inorganic Chemistry III: Coordination Chemistry (4 + 4)
9. Organic Chemistry III: Heterocyclic Chemistry (4 + 4)
10. Physical Chemistry IV: Electrochemistry (4 + 4)
11. Organic Chemistry IV: Biomolecules (4 + 4)
12. Physical Chemistry V: Quantum Chemistry & Spectroscopy (4 + 4)
13. Inorganic Chemistry IV: Organometallic Chemistry (4 + 4)
14. Organic Chemistry V: Spectroscopy (4 + 4)

Discipline Specific Elective Papers: (Credit: 06 each) (4 papers to be selected): DSE-1 to DSE-4

1. Applications of Computers in Chemistry (4) + Lab (4)
2. Analytical Methods in Chemistry (4) + Lab (4)
3. Molecular Modelling & Drug Design (4) + Lab (4)
4. Novel Inorganic Solids (4) + Lab (4)
5. Polymer Chemistry (4) + Lab (4)
6. Research Methodology for Chemistry (5) + Tutorials (1)
7. Green Chemistry (4) + Lab (4)

8. Industrial Chemicals & Environment (4) + Lab (4)
9. Inorganic Materials of Industrial Importance (4) + Lab (4)
10. Instrumental Methods of Analysis (4) + Lab (4)
11. Dissertation

Note: University/Department may include more options or delete some from this list.

Other Discipline (Four papers of any discipline, Credit: 06 each): GE-1 to GE-4

1. Mathematics (5) + Tut (1)
2. Physics (4) + Lab (4)
3. Computer Science (4) + Lab (4)/ Any other discipline of importance

Ability Enhancement Courses (AEC):

a) Ability Enhancement Compulsory Courses (Credit: 04 each):

1. English/MIL Communication/ Sanskrit/Hindi
2. Environmental Science

b) Skill Enhancement Courses (02 to 04 papers) (Credit: 04 each): SEC-1 to SEC-4

1. IT Skills for Chemists
2. Basic Analytical Chemistry
3. Chemical Technology & Society
4. Chemoinformatics
5. Business Skills for Chemists
6. Intellectual Property Rights
7. Analytical Clinical Biochemistry
8. Green Methods in Chemistry
9. Pharmaceutical Chemistry
10. Chemistry of Cosmetics & Perfumes
11. Pesticide Chemistry
12. Fuel Chemistry
13. Youth & Social Responsibilities
14. SMART Youth of Young India

Note:

1. University/Department may include more options or delete some from this list.
2. The courses will be offered according to faculty strength and as per availability of faculty members.
3. The entry and exit in the programme will be according to the relevant university ordinance.

Generic Elective Papers (GE) (Minor-Chemistry)
(any four) for other Departments/ Disciplines: (Credit: 06 each)

1. Atomic Structure, Bonding, General Organic Chemistry, Aliphatic Hydrocarbons (4 +4)
2. Chemical Energetics, Equilibria and Functional Organic Chemistry - I (4 + 4)
3. Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry - I (4 + 4)
4. Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics (4 + 4)
5. Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra (4 + 4)
6. Quantum Chemistry, Spectroscopy & Photochemistry (4 + 4)
7. Molecules of Life (4 + 4)
8. Chemistry of Main Group Elements, Theories of Acids & Bases (4 + 4)

Note:

1. University/Department may include more options or delete some from this list.
2. The courses will be offered according to faculty strength and as per availability of faculty members.

8. COURSES

Course No:	Course Name: Inorganic Chemistry-I: Atomic Structure & Chemical Bonding-I	Course Code: SBS CH 020101 C 4004

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2021 Onwards	Integrated B.Sc.-M.Sc. Chemistry	I	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** Basic knowledge about atomic structure, chemical bonding, periodic properties and redox reactions.
Course Objective	*To provide basic knowledge about atomic structure, quantum mechanics, dual nature of particles, bonding aspect, electrode potential etc.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Understanding about wave function **CO2**: Understand the periodicity in atomic and ionic radii, electronegativity, ionization energy, electron affinity of elements of the periodic table **CO3**: Understand the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect. **CO4**: In-depth knowledge about standard electrode potential and volumetric analysis **CO5**: Ability to understand, explain predict various rules involve in chemical bonding **CO6**: Understanding of anomalous behaviour of elements

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ATOMIC STRUCTURE** Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave	15

	functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.	
II	**PERIODICITY OF ELEMENTS** *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio	15
III	**CHEMICAL BONDING-I** (i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. (iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.	15
IV	**CHEMICAL BONDING-II AND OXIDATION-REDUCTION** *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing	15

	lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class	

Suggested Readings:

1. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Edition, Oxford University Press, 2014.
2. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
3. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
4. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
5. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name: Physical Chemistry-I</td><td colspan="4">Course Code:
SBS CH 020102 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>2</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of basic physical chemistry course up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students with a basic understanding of physical chemistry, gaseous, liquid and solid state and ionic equilibria. This course will strengthen the fundamentals of physical chemistry, especially gaseous state, liquid state and solid state.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of physical chemistry.
CO2: Use of gaseous, liquid and solid-state techniques in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important methods.
CO5: Development of alternate theoretical methods.
CO6: Use of advanced and recent techniques in physical chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**GASEOUS STATE** Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.	15

	Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behavior, mention of other equations of state (Berthelot, dielectric or Dieterici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.	
II	**LIQUID STATE** Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water. Different bonding present in solid and liquid state of water. Difference in structure of liquid and solid state of water.	15
III	**SOLID STATE** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.	15
IV	**IONIC EQUILIBRIA** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.	15

	Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.	

Suggested Readings:

1. P. W. Atkins, and J. D. Paula, Atkin's Physical Chemistry, 10^{th} Edition, *Oxford University Press* (2014).
2. T. Engel, and P. Reid, Physical Chemistry 3^{rd} Edition, *Pearson* (2013).
3. R. G. Mortimer, Physical Chemistry 3^{rd} Edition, *Elsevier,* NOIDA, UP (2009).
4. D. W. Ball, Physical Chemistry, *Thomson Press*, India (2007).
5. G. W. Castellan, Physical Chemistry 4^{th} Edition, *Narosa Publication House* (2004).

Course No:	Course Name: Inorganic Chemistry Practical-I	Course Code: SBS CH 020103 C 0042

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2021 onwards	Integrated B.Sc.-M.Sc. Chemistry	I	0	0	4	2	Total Hrs.: 60

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration:** **6 Hrs.** **Pre-requisite of course:** Skill to handle preparation of various solutions, estimation of metal ions in the sample during performing experiments.
Course Objective	*To acquire the skills to know about titrimetric analysis, acid-base titrations and oxidation-reduction titrimetry during the experiments. Also to carry out separation of mixtures of inorganic compounds by different methods.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Basic knowledge of inorganic preparation **CO2:** Preparation of various solutions **CO3:** Separation of ions from the mixtures **CO4:** Estimation of ions from the mixtures **CO5:** Knowledge about indicators **CO6:** To work-up, isolate and purify, determine the purity of the prepared compound

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**TITRIMETRIC ANALYSIS** (i) Calibration and use of apparatus (ii) Preparation of solutions of different Molarity/Normality of titrants **ACID-BASE TITRATIONS** (i) Estimation of carbonate and hydroxide present together in mixture. (ii) Estimation of carbonate and bicarbonate present together in a mixture. (iii) Estimation of free alkali present in different soaps/detergents	35
III	**OXIDATION-REDUCTION TITRIMETRY** (i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution. (ii) Estimation of oxalic acid and sodium oxalate in a given mixture. (iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.	25

Suggested Readings:

1. J. Mendham, A. I. Vogel's *Quantitative Chemical Analysis 6th Edition,* Pearson, 2009.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Physical Chemistry Practical-I</td><td colspan="4">Course Code:
SBS CH 020104 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week:</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students with a basic understanding of laboratory techniques. This course will strengthen the fundamentals of analytical chemistry, and basics of physical chemistry practical techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of physical chemistry practical.
CO2: Use of surface tension, viscosity and indexing techniques in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate testing methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE: Depending on availability of time and equipment's, some experiments may be added/ deleted.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">Surface tension and Viscosity Measurements.
a. Determine the surface tension by (i) drop number (ii) drop weight method.
b. Study the variation of surface tension of detergent solutions with concentration.
c. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and(iii) sugar at room temperature.
d. Study the variation of viscosity of sucrose solution with the concentration of solute.</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">Indexing by powder diffraction method of a cubic crystalline system.
a. Finding Miller indices of unknown XRD using JCPDS card file.
b. Determination of average particle size using Scherrer equation.
pH metry
a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH</td><td>30</td></tr>
</table>

	i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base. d. Determination of dissociation constant of a weak acid.	

Suggested Readings:

1. R. Gupta, Practical Physical Chemistry, *New Age International Pub. House*, New Delhi (2017).
2. B. D. Khosla, V. C. Garg, and A . Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi (2011).
3. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition; *McGraw-Hill,* New York (2003).
4. A. M. Halpern, and G. C. Mc. Bane, Experimental Physical Chemistry 3rd Edition, *W.H. Freeman & Co.,* New York (2003).

Course No:	Course Name: Organic Chemistry-I: Basics & Hydrocarbons						Course Code: SBS CH 020201 C 4004
Batch: 2021 onwards	**Programme:** Integrated B.Sc.- M.Sc. Chemistry	**Semester:** **II**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** Basic knowledge of chemical structures of the simple organic compounds.
Course Objective	*To provide basic knowledge of organic chemistry, reactions such as addition reactions, elimination and substitution reactions, stereochemistry and basic chemistry of alkanes, alkenes, alkynes and aromatic hydrocarbons , cycloalkanes and conformational analysis.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Thorough knowledge of basics of organic chemistry **CO2**: Basic understanding of stereochemistry **CO3**: Basic chemistry of alkanes and alkenes **CO4**: Ability to understand, explain and predict various aspects of cycloalkanes and conformational analysis.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BASICS OF ORGANIC CHEMISTRY** Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.	15

	Formulae representation: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions;	
II	**STEREOCHEMISTRY** Isomerism: Types of isomerism, Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. Cycloalkanes and Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.	15
III	**ALKANES AND ALKENES** Carbon-Carbon sigma bonds**:** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. Carbon-Carbon pi bonds**:** Formation of alkenes and alkynes by elimination reactions Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.	15
IV	**ALKYNES AND AROMATIC HYDROCARBONS** Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.	15

Suggested Readings:

1. J. Singh, L.D.S. Yadav, Organic Chemistry (Volume I), 14^{th} Edition, Pragati Prakashan, 2019.
2. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
3. R. N. Boyd, R. T. Morrison and S. K. Bhattcharjee, Organic Chemistry, 7^{th}Edition, Pearson, 2014.
4. S. M. Mukerji, S. P. Singh, K.P. Kapoor and R. Das, Organic Chemistry (Volume III), 2^{nd} Edition, New Age International Publishers, 2014.
5. J. E. McMurry, Fundamentals of Organic Chemistry, 7^{th}Edition, Cengage Learning India, 2013.
6. S. M. Mukerji, S. P. Singh, K.P. Kapoor and R. Das, Organic Chemistry (Volume II), 2^{nd} Edition, New Age International Publishers, 2012.
7. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2^{nd} Edition, New Age International Publishers, 2010.
8. P. S. Kalsi, Stereochemistry Conformation and Mechanism, New Age International, 2005.
9. I. L. Finar, Organic Chemistry (Volume 1), 6^{th} Edition, Pearson, 2002.
10. I. L. Finar, Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), 5^{th} Edition, Pearson, 2002.
11. E. L. Eliel & S. H. Wilen, Stereochemistry of Organic Compounds, Wiley: London, 1994.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Physical Chemistry-II</td><td colspan="4">Course Code:
SBS CH 020202 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of basic physical chemistry course up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students with a basic understanding of chemical thermodynamics, and chemical equilibrium. This course will strengthen the fundamentals of thermodynamics, especially chemical thermodynamics, and chemical equilibrium.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic understanding of chemical thermodynamics.
CO2: Use of chemical thermodynamics in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important chemical methods.
CO5: Development of alternate physical chemistry methods.
CO6: Use of advanced and recent chemical thermodynamic chemistry.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHEMICAL THERMODYNAMICS-I** Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. *Second Law:* Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. *Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.	15

II	**SYSTEMS OF VARIABLE COMPOSITION and CHEMICAL THERMODYNAMICS-II** Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **CHEMICAL THERMODYNAMICS-II** *Thermochemistry:* Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature. *Free Energy Functions:* Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.	15
III	**CHEMICAL EQUILIBRIUM** Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.	15
IV	**SOLUTIONS AND COLLIGATIVE PROPERTIES** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.	15

Suggested Readings:

1. A. Peter, and J. Paula, Physical Chemistry 10^{th} Edition, *Oxford University Press* (2014).
2. T. Engel, and P. Reid, Physical Chemistry 3^{rd} Edition, *Prentice-Hall* (2012).
3. M. J. Assael, A. R. H. Goodwin, M. Stamatoudis, W. A. Wakeham, and S. Will, Commonly asked questions in thermodynamics. *CRC Press*, New York (2011).
4. I. N. Levine, Physical Chemistry 6^{th} Edition, *Tata Mc Graw Hill* (2010).
5. C. R. Metz, 2000 solved problems in chemistry, *Schaum Series* (2006).
6. G. W. Castellan, Physical Chemistry 4^{th} Edition, *Narosa* (2004).
7. D. A. McQuarrie, and J.D. Simon, Molecular Thermodynamics, *Viva Books Pvt. Ltd*., New Delhi (2004).

Course No:	Course Name: Organic Chemistry Practical-I	Course Code SBS CH 020203 C 0042

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 02
2021 onwards	Integrated B.Sc.- M.Sc. Chemistry	II	0	0	4	2	**Total Hrs: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration:** **6 Hrs.** **Pre-requisite of course:** Common understanding of chemicals.
Course Objective	*To inculcate the common skills required for performing organic chemistry practicals like m.p. and b.p. determination, crystallization and separation of compounds by thin layer chromatography.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** About the calibration of thermometer and its uses **CO2**: Determination of b.p. and m.p. of the organic compounds purification of organic compounds **CO3:** About the use of thin layer chromatography

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt both questions.

Unit No.	Contents	Contact Hrs.
I	1. Checking the calibration of the thermometer 2. Purification of organic compounds by crystallization using the following solvents: a) Water b) Alcohol c) Alcohol-Water 3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)	30
II	4.Effect of impurities on the melting point – mixed melting point of two unknown organic compounds 5.Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method) 6.Chromatography	30

	a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography b. Separation of a mixture of two sugars by ascending paper chromatography c. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC)	

Suggested Readings:

1. B.S. Furniss ; A. J. Hannaford ; P.W.G. Smith ; A. R. Tatchell, Practical Organic Chemistry, 5th Edition., Pearson, 2012.
2. F.G. Mann & B.C. Saunders, Practical Organic Chemistry, Pearson, 2009.

Course No:	Course Name: Physical Chemistry Practical-II						Course Code: SBS CH 020204 C 0042
Batch: 2021 onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** II	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			0	0	4	2	**Total Hrs.: 60**
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** **6** Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to Sen. Sec. level.						
Course Objectives	*To provide students with a basic understanding of laboratory techniques. This course will strengthen the fundamentals of analytical chemistry, and basics of physical chemistry practical techniques.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of physical chemistry practical. **CO2**: Use of surface tension, viscosity and indexing techniques in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate testing methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.						

COURSE SYLLABUS

NOTE: Depending on availability of time and equipment's, some experiments may be added/ deleted.

Unit No.	Contents	Contact Hrs.
I	**THERMOCHEMISTRY-I** (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization). (b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide. (c) Calculation of the enthalpy of ionization of ethanoic acid. (d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.	30
II	**THERMOCHEMISTRY-II** (a) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.	30

	(b) Determination of enthalpy of hydration of copper sulphate. (c) Study of the solubility of benzoic acid in water and determination of ΔH.	

Suggested Readings:

1. R. Gupta, Practical Physical Chemistry, *New Age International Pub. House*, New Delhi (2017).
2. J. B. Yadav, Advanced Practical Physical Chemistry, *Krishana Prakashan Media, Pvt. Ltd*. (2015).
3. B.D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi (2011).
4. V. D. Athawale, and P. Mathur, Experimental Physical Chemistry, *New Age International*, New Delhi (2001).
5. A. M. Halpern, and G.C. Mc Bane, Experimental Physical Chemistry 3rd Edition, *W.H. Freeman & Co.,* New York (2003).

Course No:	**Course Name:** Environmental Science	**Course Code:** EVS/ SBS EVS 0107 AECC 4004

Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc.	**Semester:** I or II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:** **04**
			4	0	0	4	**Total Hrs.:** **60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** None

Course Objective	*To aware the students the need for sustainable development, problems of pollution, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, the depletion of ozone layer, loss of biodiversity and need of worldwide efforts in its conservation.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: The students will get the knowledge about trends of biological diversity and conservation strategies and thereafter be able to create awareness for its conservation and development. **CO2**: The understanding of issues concerning different natural resources will be helpful to find scientific solution based on participatory approach. **CO3**: To know about the local environmental issues, movements and an important role to minimize the impact of these aspects. **CO4**: Knowledge about the types of pollution and pollution control.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**INTRODUCTIONTO ENVIRONMENTAL SCIENCES** Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.	15

II	**ECOSYSTEM** Introduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems.	15
III	**BIODIVERSITY AND ITS CONSERVATION** Introduction – Definition, value and types: genetic, species and ecosystem diversity. Bio-geographical classification and Hot-spots of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation.	15
IV	**ENVIRONMENTAL ISSUES AND POLICIES** Definition, cause, effects and control measures of Air, Water, Soil, Marine and Noise pollution. Solid Waste Management: Causes, effects and control measures of wastes. Seventeen Sustainable Developmental Goals, Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, Public awareness.	15

Suggested Readings:

1. D. Thangadurai, G. Ching, S. Jeyabalan, and S. Islam Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. United States: Apple Academic Press, 2019
2. I. Khan, Forest Governance and Sustainable Resource Management. SAGE Publications. India, 2019
3. P. D. Sharma, Ecology and Environment. 13th Edition, Rastogi Publications, 2017
4. G. Cao, R. Orru, Current Environmental Issues and Challenges. 14th Edition; Springer, 2014
5. D. Ginley, D. Cahen, Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press, 2011
6. R. K. Trivedi, Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards, 3rd Edition. BS Publications, 2010
7. M. C. Dash, S. P. Dash, Fundamentals of Ecology. 3rd McGraw Hill Education, 2009
8. W. P. Cunningham, M. A. Cunningham, Principles of Environment Science. Enquiry and Applications. 5th Edition. Tata McGraw Hill, New Delhi, 2008
9. J. Gibbs, L. Malcolm, J. Sterling, Problem-Solving in Conservation Biology and Wildlife Management. 2nd Edition, Wiley-Blackwell,2008
10. M. Gilbert, An Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi, 2007
11. E. P. Odum, W. Barrett, Fundamentals of Ecology. 5th Edition, Cengage Learning, 2005
12. E. Bharucha, The Biodiversity of India, Mapin Publishing, 2002

<table>
<tr><td colspan="1">Course No:</td><td colspan="5">Course Name:
English Communications</td><td colspan="3">Course Code:
SBS ENG 0207 AECC 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc.</td><td rowspan="2">Semester:

I or II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="8">The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in the vital communication skills which should be integral to personal, social and professional interactions.</td></tr>
</table>

Course Outcomes:	After completing this course, student is expected to develop the following skills: **CO1**: Ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. **CO2**: Enhancement in effective communication. **CO3**: Various dimensions of communication skills. **CO4:** Enhancement in writing skills such as report writing, note-taking etc.

COURSE SYLLABUS

NOTE:

i i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION AND COMMUNICATION** Introduction: Theory of Communication, Types and modes of Communication Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication.	15
II	**SPEAKINGSKILLS** Speaking Skills: Monologue, Dialogue, Group Discussion, Effective Communication/ Mis-Communication, Interview, Public Speech	15
III	**READINGANDUNDERSTANDING** Reading and Understanding, Close Reading, Comprehension, Summary Paraphrasing, Analysis and Interpretation, Translation (from Indian language to English and vice-versa), Literary/Knowledge Texts	15
IV	**WRITINGSKILLS** Writing Skills, Documenting, Report Writing, Making notes, Letter writing	15

Suggested Readings:

1. O. Blackswan, Language, Literature and Creativity, 2013.
2. Business English, Pearson, 2008.
3. Fluency in English-Part II, Oxford University Press, 2006.
4. Dr. G. Mishra, Dr. R. Kaul and Dr. B. Biswas, Language through Literature (forthcoming) Edition.

Course No:	Course Name: Sanskrit					Course Code: SBS SKT 0209 AECC 4004		
Batch: 2021 onwards	**Programme:** Integrated B.Sc.-M.Sc.	**Semester:** I or II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:**	**04**
			4	0	0	4	**Total Hrs.:**	**60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** None

Course Objective/ □□□□□□□□□□	**1.** □□□□□□□□□□□-□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□; **2.** □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□-□□□□□□□□□□□□□□□□□□□□□□ □ □□□□□□□□□□□□□□□□; **3.** □□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□ □□□□□□□□ □□□□□□□□□□ □□□□□□□□□□□ □ □□□□□□□-□□□□□□□□□ □□□□□; **4.** □□□□□□□□-□□□□□□□□□□□□□□□□ □□□□□□□□
Course Outcomes/ □□□□□□□□□ □□□□□□□□□□ □ □□□□	After completing this course, student is expected to develop the following skills: **CO1**: □□□□□□□□□□ □□□□□□□-□□□□□□□□□□□□□□□□□□□□□ □ □□□□□□□□□□ □□□□□□□□□ □□□□□□□□□□ □□□□□□□□□□□□□ □□□□□□□□ **CO2**: □□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□ □□□□□□□ □□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□- □□□□□□□□□□□□ □□□□□□□□□□□ □□□□□ □□□□□□□□□□ □□□□□□□ **CO3**: □□□□□□□□□□□–□□□□–□□□□□□□□□□□□–□□□□□□□□□□□□□□□□□□ □□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□ □□□□□□□□□□ □□□□□□□ □□□□□□□□□ **CO4:** □□□□□□□-□□□□□□□□□□□□□□□□□□ □□□□□□□□□ □□□□□□□□□□ □□□□□□□□□□□ □□□□□□□□□□□□□□□□ □□□□□□□□□

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NOTE:

i i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	□□□□□-**1**: **(**□**)** □□□□□□□□□□ **(34. 1-6)-**□□□□□□□□□□□□□□□□□□□; **(**□**)** □□□□□□□□□□□□□□□□□□ **-** □□□□□□□□□□□□ **(**□□□□□□□□□□□□□□□□**)**	15
II	□□□□□-**2**:	15

	[illegible]- [illegible] : **1-50** [illegible]	
III	[illegible]**-3**: [illegible] – [illegible] **(**[illegible]**)**	15
IV	[illegible]**-4**: [illegible]- **(**[illegible]**)** [illegible], [illegible]; (…) [illegible], [illegible], [illegible]	15

[illegible] **-**

1. [illegible]**-**[illegible]**,** [illegible]**,** [illegible]**,** [illegible], **2007**

2. [illegible]**,** [illegible]**,** [illegible]**,** [illegible]**,** [illegible] **(**[illegible]**)**

3. [illegible]**,** [illegible] **-** [illegible]**,** [illegible], **2013**

4. [illegible]**,** [illegible]**,** [illegible] **-** [illegible]**,** [illegible]**,** [illegible]**, 2014**

5. [illegible]**,** ‘[illegible]’ [illegible] **-** [illegible]**,** [illegible]**,** [illegible]

6. [illegible] **(**[illegible]**),** [illegible]**,** [illegible], **2015**

7. [illegible]**,** [illegible] **(**[illegible]**,** [illegible]**)**, 2005

8. [illegible]**,** [illegible]**,** [illegible]**,** [illegible]**,** [illegible]**, 1990**

9. [illegible]**,** [illegible]**-**[illegible]**-**[illegible]**,** [illegible]**,** [illegible]**,** [illegible], **2012**

1**0.** [illegible]**,** [illegible]**,** [illegible]**,** [illegible]

1**1.** Burrow, T.**,** The Sanskrit Language**,** 2016

1**2.** Gune, P.D., An Introduction to Comparative Philology, Oriental Book House, Poona, 1958

13. The Taittirīya Upaniṣad, Eng. Tr. and Commentary by Swami Muni Narayana Prasad, D.k. Print world (P), Ltd., New Delhi-2009

14. The Nīti and Vairāgya Śatakas of Bhartrihari, M.R. Kale, Motilal Banarsidass, Delhi, 2017

Semester III

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Inorganic Chemistry-II: s and p- Block Elements</td><td colspan="3">Course Code:
SBS CH 020301 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Idea of metallurgy, HSAB principle, chemistry of s and p Block Elements, inorganic polymers, occurrence and uses of noble gases.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of Principles of metallurgy, concept of acid-base reactions, Chemistry of s and p Block Elements, occurrence and nature of bonding in noble gas compounds.</td></tr>
</table>

Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of principles of metallurgy **CO2:** Understanding the concept of acid-base reactions **CO3:** Understanding the basic properties of elements of s and p Block **CO4:** Understanding of occurrence and nature of bonding in noble gas compounds **CO5:** Understanding the Types of inorganic polymers **CO6:** Scope of inorganic compounds/polymers

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**GENERAL PRINCIPLES of METALLURGY** Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.	15
II	**ACIDS AND BASES** Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.	15
III	**CHEMISTRY OF S AND P BLOCK ELEMENTS** Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. Synthesis, structural aspects and applications of silicones and siloxanes, borazines, silicates and phosphazenes, and polysulphates.	15
IV	**NOBLE GASES** Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).	15

Suggested Readings:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B. E; Mc Daniel, D. H. & Alexander, J. J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010.
7. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Course No:	**Course Name:** Organic Chemistry-II: Oxygen Containing Functional Groups				**Course Code:** SBS CH 020302 C 4004		
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** III	**L** 4	**T** 0	**P** 0	**Credits** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Chemistry of halogenated hydrocarbons, preparation and properties of alcohols, phenols, ethers and epoxides, addition reactions of carbonyl compounds, carboxylic acids and their derivatives, Sulphur containing compounds					
Course Objectives	*To provide students with basic understanding of* chemistry of halogenated hydrocarbons, preparation and properties of alcohols, phenols, ethers and epoxides, structure reactivity and preparation of carbonyl compounds, carboxylic acids and their derivatives, preparation and reactions of Sulphur containing compounds						

Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of chemistry of halogenated hydrocarbons **CO2:** Understanding of preparation and properties of alcohols, phenols, ethers and epoxides **CO3:** Understanding of addition reactions of carbonyl compounds **CO4:** Understanding the preparation, physical properties and reactions of carboxylic acids **CO5:** Understanding the preparation and reactions of Sulphur containing compounds **CO6:** Scope of organic reactions

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CHEMISTRY OF HALOGENATED HYDROCARBONS** Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.	15
II	**ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES** Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement; Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism; Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$	15

III	**CARBONYL COMPOUNDS** Structure, reactivity and preparation. Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α- substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	15
IV	**CARBOXYLIC ACIDS AND THEIR DERIVATIVES** Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement.	15

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Physical Chemistry-III</td><td colspan="4">Course Code:
SBS CH 020303 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of basic physical chemistry course up to Sen. Sec. level.</td></tr>
</table>

Course Objectives	*To provide students with a basic understanding of phase equilibria, chemical kinetics, and surface chemistry. This course will strengthen the fundamentals of equilibria, especially phase equilibria and kinetics of chemical reactions.*
Course Outcomes:	After completing this course, the student is expected to learn the following: **CO1:** Basic understanding of the concept of phases and phase diagrams. **CO2:** Learn about binary solutions. **CO3:** Have an understanding of rate law and rate of reaction. **CO4:** Understanding theories of reaction rate and catalysis. **CO5:** Use of surface chemistry

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and a half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**PHASE EQUILIBRIA I** Concept of phases, components, and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour, and solid-vapour equilibria, the phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three-component systems, water-chloroform-acetic acid system, triangular plots.	**15**
II	**PHASE EQULIBRIA II** *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.	**15**
III	**CHEMICAL KINETICS** Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions, and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates.	**15**
IV	**CATALYSIS AND SURFACE CHEMISTRY**	**15**

	Types of catalyst, specificity, and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Physical adsorption, Chemisorption, adsorption isotherms (Langmuir and Freundlich), nature of the adsorbed state, and Qualitative discussion of BET.	

Suggested Readings:

1. Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked* Questions in Thermodynamics. CRC Press: NY (2011).
6. Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
7. Ball, D. W. *Physical Chemistry* Cengage India (2012).
8. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
9. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
10. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Inorganic Chemistry Practical-II</td><td colspan="3">Course Code:
SBS CH 020304 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Iodo / iodimetric titrations, inorganic preparations</td></tr>
</table>

Course Objectives	*To provide students with basic understanding of* Iodo / iodimetric titrations, preparation of inorganic compounds	
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of Estimation of ions by Iodimetrically / iodometrically **CO2:** Understanding of Preparation of inorganic compounds **CO3:** Learn Inorganic chemistry through experiments	
COURSE SYLLABUS		
NOTE: Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.		
Unit No.	**Contents**	**Contact Hrs.**
I	**IODO / IODIMETRIC TITRATIONS** (i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically (iii) Estimation of available chlorine in bleaching powder iodometrically.	30
II	**INORGANIC PREPARATIONS** (i) Cuprous Chloride, Cu_2Cl_2 (ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$ (iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.	30
Suggested Readings: 1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.		

Course No:	**Course Name:** Organic Chemistry Practical-II				**Course Code:** SBS CH 020305 C 0042		
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** III	**L** 0	**T** 0	**P** 4	**Credits** 2	**Contact Hrs. per Week:** **04** **Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs.					
		Pre-requisite of course: functional group tests, preparation of Organic compounds					

Course Objectives	*To provide students with basic understanding of* functional group tests, preparation of Organic compounds
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group. **CO2:** Understanding of preparation of inorganic compounds **CO3:** Learn organic chemistry through experiments

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**FUNCTIONAL GROUP TESTS** for alcohols, phenols, carbonyl and carboxylic acid group.	30
II	**ORGANIC PREPARATIONS** i. Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: a. Using conventional method. b. Using green approach ii. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Bromination of any one of the following: a. Acetanilide by conventional methods b. Acetanilide using green approach (Bromate-bromide method) v. Nitration of any one of the following: a. Acetanilide/nitrobenzene by conventional method b. Salicylic acid by green approach (using ceric ammonium nitrate). vi. Selective reduction of meta dinitrobenzene to m-nitroaniline. vii. Reduction of p-nitrobenzaldehyde by sodium borohydride. viii. Hydrolysis of amides and esters. ix. Semicarbazone of any one of the following compoundsacetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. x. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). xi. Aldol condensation using either conventional or green method. xii. Benzil-Benzilic acid rearrangement.	30

	The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.	

Suggested Readings:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

Course No:	**Course Name:** Physical Chemistry Practical-III				**Course Code:** SBS CH 020306 C 0042		
Batch: 2021 onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
		III	**0**	**0**	**4**	**2**	**Total Hrs.: 60**
Total Evaluation Marks: 50		**Examination Duration: 6 Hrs.**					
CIE: 15 Marks **TEE: 35 Marks**		**Pre-requisite of course:** Knowledge of solution preparation and safety measure in a chemistry practical laboratory.					

Course Objectives	*To inculcate the common skills required for performing simple Physical Chemistry Practical.*
Course Outcomes:	After completing this course, the student is expected to learn the following: **CO1:** Basic understanding of practical physical chemistry. **CO2:** Use of adsorption in daily life. **CO3:** Analyzing the kinetics of the chemical reaction. **CO4:** Use of pH meter **CO5:** Use of advanced and recent techniques in experimental chemistry.

COURSE SYLLABUS

NOTE: Depending on the availability of time and equipment, some experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**PHASE EQUILIBRIA AND KINETICS** (a) Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it. (b) Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: (i) Simple eutectic and (ii) Congruently melting systems. (c) Distribution of acetic/ benzoic acid between water and cyclohexane. (d) Study the kinetics of the following reactions. 1. Initial rate method: Iodide-persulphate reaction 2. Integrated rate method: a. Acid hydrolysis of methyl acetate with hydrochloric acid. b. Saponification of ethyl acetate.	**30**
II	**ADSORPTION AND pH METRY TITRATION** Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal. Perform the following pH metric titrations i. Strong acid vs weak base ii. Weak acid vs weak base	**30**

Suggested Readings:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Semester IV

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Inorganic Chemistry-III: Coordination Chemistry</td><td colspan="3">Course Code:
SBS CH 020401 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: Basic understanding of coordination chemistry, transition elements, lanthanoids and actinoids, bioinorganic chemistry</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of coordination chemistry, general properties of transition elements transition elements, lanthanoids and actinoids, bioinorganic chemistry</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understanding of coordination chemistry
CO2: Understanding the general properties of transition elements
CO3: Understanding the electronic configuration and magnetic properties, lanthanoids and actinoids
CO4: Understanding of application of metal ions present in biological systems,
CO5: Scope of inorganic compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**COORDINATION CHEMISTRY** Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.	15
II	**TRANSITION ELEMENTS**	15

	General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)	
III	**LANTHANOIDS AND ACTINOIDS** Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).	15
IV	**BIOINORGANIC CHEMISTRY** Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.	15

Suggested Readings:

1. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth- Heinemann, 1997.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Organic Chemistry-III: Heterocyclic Chemistry</td><td colspan="3">Course Code:
SBS CH 020402 C 4004</td></tr>
<tr><td>Batch:
2021</td><td>Programme:
Integrated B.Sc.-</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
</table>

Onwards	M.Sc. Chemistry	IV	4	0	0	4	**Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of nitrogen containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, alkaloids, terpenes					
Course Objectives	*To provide students with basic understanding of* nitrogen containing functional groups, preparation of polynuclear hydrocarbons, introduction of heterocyclic compounds, general features of alkaloids, terpenes						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of preparation and important reactions of nitrogen containing compounds **CO2:** Understanding of preparation and structure elucidation of polynuclear hydrocarbons, **CO3:** Understanding of classification, nomenclature, structure, aromaticity in heterocyclic compounds **CO4:** Understanding the natural occurrence, general structural features of natural occurrence, general structural features of alkaloids **CO5:** Understanding the occurrence, classification, and structure elucidation of terpenes **CO6:** Scope of organic compounds						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**NITROGEN CONTAINING FUNCTIONAL GROUPS** Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications.	15
II	**POLYNUCLEAR HYDROCARBONS** Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.	15

III	**HETEROCYCLIC COMPOUNDS** Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.	15
IV	**ALKALOIDS** Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.	15
V	**TERPENES** Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.	15

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

Course No:	**Course Name:** Physical Chemistry-IV	**Course Code:** SBS CH 020403 C 4004

<table>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

IV</td><td>L

4</td><td>T

0</td><td>P

0</td><td>Credits

4</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 Hrs.

Pre-requisite of course: Basic understanding of conductance, electrochemistry, electrical & magnetic properties of atoms and molecules</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of applications of conductance measurement, electrochemistry, electrical & magnetic properties of atoms and molecules</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of Physical Chemistry.
CO2: Applications of Electrochemistry techniques and Polymers in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing new technical methods for industrial purposes.
CO5: Development of alternate theoretical methods.
CO6: Use of advanced and recent techniques in physical chemistry.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CONDUCTANCE** Arrhenius's theory of electrolytic dissociation. Conductivity, equivalent, and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water.	15
II	**ELECTROCHEMISTRY** Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, application of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. The Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to	15

	different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy, and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, Quinone-hydroquinone, glass, and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers.	
III	**ELECTRICAL & MAGNETIC PROPERTIES OF ATOMS AND MOLECULES** Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment, and molecular polarizabilities and their measurements. Diamagnetism, para-magnetism, magnetic susceptibility and its measurement, molecular interpretation.	15
IV	**POLYMER: AN INTRODUCTION** Historical development of polymer chemistry. Monomers, polymers, repeating units, functionality. Nomenclature of polymers. Classification of polymers. Importance and applications of polymers – acrylic, vinyl, cellulose, fluorinated, polyethylene, and conducting polymers. Degree of polymerization and molecular weight. Concept of average molecular mass and molecular mass distribution. Number average, and weight average molecular mass.	

Suggested Readings:

1. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
2. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
3. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
5. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
6. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
7. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).

Course No:	**Course Name:** Inorganic Chemistry Practical-III				**Course Code:** SBS CH 020404 C 0042		
Batch: 2021	**Programme:** Integrated B.Sc.-	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**

Onwards	M.Sc. Chemistry	IV	0	0	4	2	**Total Hrs.:**	**60**

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Basic understanding of gravimetric analysis of ions, preparation of inorganic compounds, chromatography of metal ions
Course Objectives	*To provide students with basic understanding of* gravimetric analysis of ions, preparation of inorganic compounds, introduction of chromatography of metal ions
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of estimation of metal ions **CO2:** Understanding the preparation of inorganic compounds **CO3:** Understanding of chromatography of metal ions **CO4:** Scope of inorganic compounds

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**GRAVIMETRIC ANALYSIS** i. Estimation of nickel (II) using Dimethylglyoxime (DMG). ii. Estimation of copper as CuSCN iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$. iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).	30
II	**CHROMATOGRAPHY AND INORGANIC PREPARATIONS:** i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$ ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III) iii. Tetraamminecarbonatocobalt (III) ion iv. Potassium tris(oxalate)ferrate(III) Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Fe (III) and Al (III)	30

Suggested Readings:
1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

Course No:	Course Name:	Course Code:
	Organic Chemistry Practical-III	SBS CH 020405 C 0042

<table>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of detection of extra elements, functional group test for nitro, amine and amide groups, qualitative analysis of unknown organic compounds</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of detection of extra elements, functional group test for nitro, amine and amide groups, qualitative analysis of unknown organic compounds</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understanding of detection of extra elements
CO2: Understanding of qualitative analysis of unknown organic compounds
CO3: Scope of organic compounds</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**FUNCTIONAL GROUP TEST** Functional group test for Nitro, amine and amide groups. Detection of extra elements	30
II	**QUALITATIVE ANALYSIS** Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)	30

Suggested Readings:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Physical Chemistry Practical-IV</td><td colspan="4">Course Code:
SBS CH 020406 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of conductometry and potentiometry,</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with basic understanding of conductometry and potentiometry,</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understanding of determination of cell constant and equivalent conductance
CO2: Titration handlings by using a potentiometer and conductivity meter.
CO3: Skill development for qualitative and quantitative analysis.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">CONDUCTOMETRY
I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Mixture of strong acid and weak acid vs. strong base
iv. Strong acid vs. weak base</td><td>30</td></tr>
<tr><td>II</td><td colspan="6">POTENTIOMETRY
I Perform the following potentiometric titrations:
i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Dibasic acid vs. strong base</td><td>30</td></tr>
</table>

	iv.	Potassium dichromate vs. Mohr's salt	

Suggested Readings:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Note:

1. Students may be encouraged or may opt courses which are available online (SWAYAM, MOOCS etc.).

List of Skill Enhancement Courses

Sr. No.	Name of the course	Course Code	L/P	T	P	Credits
1	Basic Analytical Chemistry	SBS CH 020301 SE 4004	4	0	0	**4**
2	Chemistry of Cosmetics & Perfumes	SBS CH 020302 SE 4004	4	0	0	**4**
3	Cheminformatics	SBS CH 020303 SE 4004	4	0	0	**4**
4	Pharmaceutical Chemistry	SBS CH 020304 SE 4004	4	0	0	**4**
5	Intellectual Property Rights	SBS CH 020405 SE 4004	4	0	0	**4**
6	Pesticide Chemistry	SBS CH 020406 SE 4004	4	0	0	**4**
7	Analytical Clinical Biochemistry	SBS CH 020407 SE 4004	4	0	0	**4**

Note:

2. University/Department may include more options or delete some from this list.
3. The courses will be offered according to faculty strength and as per availability of faculty members.

Course No:	**Course Name:** Basic Analytical Chemistry					**Course Code:** SBS CH 020301 SE 4004	
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.- M.Sc. Chemistry	**Semester:** III	**L** 4	**T** 0	**P** 0	**Credits** 4	**Contact Hrs. per Week:** **04** **Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Knowledge of analytical methods in Chemistry, and different techniques used in the research laboratory.					
Course Objectives	*To skill students in analytical methods, types, proper selection of analytical methods in research and their applications*						
Course Outcomes:	After completing this course, a student is expected to learn the following: **CO1:** Understanding of prospects of analytical techniques **CO2:** Understanding of different analytical techniques **CO3:** Understanding how to apply different analytical techniques **CO4:** Understanding the properties of compounds and structure and properties based on analytical techniques. **CO5:** Understanding the basics of different analytical techniques. **CO6:** Understanding of different separation techniques						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and a half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q, and t-test, rejection of data, and confidence intervals. Origin of spectra, the interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.	15
II	**OPTICAL METHODS OF ANALYSIS** *UV-Visible spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.	15

	Infrared spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instruments; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.	
III	**THERMAL METHODS OF ANALYSIS** Theory of thermogravimetry (TG), Basic principle of instrumentation of TGA/DTA and DSC. Techniques for quantitative estimation of Ca and Mg from their mixture. Applications of TGA/DTA in analysis of the sample.	15
IV	**Electroanalytical methods** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pK_a values. Polarography: An introduction, principle, instrumentation, and applications.	15

Suggested Readings:

1. Mendham, J., A. I. Vogel's (2009) Quantitative Chemical Analysis *6th Ed.*, Pearson.
2. Willard, H.H. *et al.* (1988) Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company: Belmont, California, USA.
3. Christian, G.D. (2004) Analytical Chemistry, 6th Ed. John Wiley & Sons: New York.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. (1979) Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. (2008) Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons.
8. Ditts, R.V. (1974) Analytical Chemistry; Methods of separation, van Nostrand.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Chemistry of Cosmetics and Perfumes</td><td colspan="3">Course Code:
SBS CH 020302 SE 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basics understanding of Chemistry</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide a basic knowledge of the chemistry of cosmetics, the major ingredients present in most cosmetics include water, emulsifiers, preservatives, thickeners, moisturizers, dyes and fragrances.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to to provide general overview on cosmetics and perfumes.
This course has been designed to impart the theoretical and practical knowledge on basic principles of cosmetic chemistry, manufacture, formulation of various cosmetic products.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BASICS** **Cosmetics-** Definition, History, Classification, Ingredients, Nomenclature, Regulations. **Face Preparation:** Structure of skin, Face powder, Compact powder, Talcum powder. **Skin Preparation:** Face cream, vanishing cream, cold cream, suntan cream, lather shaving cream.	15
II	**HAIR PREPARATION** Structure of hair, classification of hair, Hair dye- classification – temporary, semi-permanent, demi-permanent, permanent, formulation, hair sprays, shampoo- types of shampoo, conditioners.	15
III	**COLORED PREPARATION** Nail preparation Structure of nail, Nail lacquers, Nail polish remover Lipsticks. **Personal hygiene products:** Antiperspirants and deodorants, oral hygiene products, flavors, and essential oils.	15

IV	**ESSENTIAL OILS AND ITS INDUSTRIAL APPLICATIONS** Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.	15

Suggested Readings:

1. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut, (1996).Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell (1977).

Course No:	Course Name: Cheminformatics	Course Code: SBS CH 020303 SE 4004

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2021 Onwards	Integrated B.Sc.-M.Sc. Chemistry	III	4	0	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Knowledge of computer aided support in Chemistry, related softwares.
Course Objectives	*To skill students about chemoinformatics, nomenclature, reaction classification, proper searching of chemical structures and its applications*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of prospects of chemoinformatics **CO2:** Understanding of nomenclature and reaction classification **CO3:** Understanding on how to search chemical structure **CO4:** Understanding the properties of compounds and structure and property relations **CO5:** Understanding the computational chemistry in elucidation of structure and design of synthesis **CO6:** Understanding of drug design, target identification and optimization

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO CHEMOINFORMATICS** History, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.	15
II	**REPRESENTATION OF MOLECULES AND CHEMICAL REACTIONS** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.	15
III	**SEARCHING CHEMICAL STRUCTURES** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	15

IV	**APPLICATIONS** Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modelling. Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand and structure based drug design; Applications in Drug Design.	15

Suggested Readings:

1. Andrew R. Leach and Valerie, J. Gillet, An introduction to Chemoinformatics. Springer: The Netherlands (2007).
2. Gasteiger, J. and Engel, T. Chemoinformatics: A text-book. Wiley-VCH (2003).
3. Gupta, S. P. QSAR & Molecular Modeling. Anamaya Pub.: New Delhi (2011).

Course No:	Course Name: Pharmaceutical Chemistry						Course Code: SBS CH 020304 SE 4004
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** III	**L** 4	**T** 0	**P** 0	**Credits** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of non-covalent interactions, biomolecules and biochemical processes
Course Objectives	*This course will provide a basic understanding and fundamentals of pharmaceutical chemistry, drug discovery and development process, different classes of drugs and its mechanism of action. This course will develop skills in the preparation and development of new lead compounds and their modification towards drug discovery.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** To understand basic knowledge of pharmaceutical chemistry of various classes of drugs and their mechanism of action as well as synthesis. **CO2:** An appreciation of the history of medicinal and pharmaceutical chemistry, understanding of basic biochemical functioning of living organisms, structural and functional details of bio-macromolecules such as proteins, nucleic acids and lipids. **CO3**: Advanced knowledge about Sympathomimetic Drugs and its uses. **CO4**: Strategies and tactics of development of various Psychoactive agents. Examples with synthesis. **CO5**: Basic concepts of fermentation and its applications.

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**DRUGS AND PHARMACEUTICALS** Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir).	15
II	**PSYCHOACTIVE DRUGS**	15

	Central Nervous System agents (Phenobarbital, Diazepam), Antidepressant Drugs (Amitriptyline, Nortryptyline, Imperamine, Phepelzine, Tranylcypromine), Steroidal Drugs (Betamethasone, Cortisone, Hydrocortisone, Prednisolone, Progesterone, Testosterone, Oestradiol, Nandrolone), Tranquilizers (Chlorpromazine, Prochlorperazine, Trifluoperazine, Thiothixene, Haloperiodol, Triperiodol, Oxypertine, Chlordizepoxide, Diazepam, Lorazepam, Meprobamate)	
III	**SYMPATHOMIMETIC DRUGS** Adrenergic drugs (Adrenaline, Noradrenaline, Isoprenaline, Phenylephrine, Salbutamol, Terbutaline, Ephedrne, Pseudoephedrine), Adrenergic antagonist (Tolazoline, Propranolol, Practolol), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine),	15
IV	**FERMENTATION** Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.	15

Suggested Readings:

1. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
2. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012
3. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.
4. Government of India, Ministry of Health. (1955). Pharmacopoeia of India:(the Indian pharmacopoeia). Delhi:Manager of Publications
5. Pharmaceutical Society of Great Britain. (19071973). British pharmaceutical codex.London :Pharmaceutical press.
6. Martindale: The extra pharmacopeia, 28th Ed. Edited By James E. F. Reynolds and Anne B. Prasad. The Pharmaceopeial Press, 1 Lamberth High Street, London, SE1 7JN

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Intellectual property Rights</td><td colspan="5">Course Code:
SBS CH 020405 SE 4004</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:
IV</td><td>L
4</td><td>T
0</td><td>P
0</td><td>Credits
4</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: Knowledge of intellectual property rights, and copyrights.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To skill students about intellectual property rights, copyrights, international agreements, patents, and patent filing.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, a student is expected to learn the following:
CO1: Understanding of prospects of patent filling
CO2: Understanding of Copyrights
CO3: Understanding Trademarks
CO4: Understanding the different international agreements
CO5: Understanding the Paris convention
CO6: Understanding the difference between trademark copyright and patent.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO INTELLECTUAL PROPERTY** Historical Perspective, Different Types of IP, Importance of protecting IP. **Copyrights** Introduction, How to obtain, Differences from Patents. **Trade Marks** Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.	15
II	**PATENTS** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India. **Geographical Indications**	15

	Definition, rules for registration, prevention of illegal exploitation, importance to India. **Industrial Designs** Definition, How to obtain, features, International design registration.	
III	**DIFFERENT INTERNATIONAL AGREEMENTS** **(a) Word Trade Organization (WTO):** (i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade-related Services (GATS) (iii) Madrid Protocol (iv) Berne Convention (v) Budapest Treaty	15
IV	**PARIS CONVENTION** **WIPO** and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity **IP Infringement issue and enforcement** – Role of Judiciary, Role of law enforcement agencies – Police, Customs, etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India Licensing and technology transfer.	15

Suggested Readings:

1. Acharya, N.K. (2001) Textbook on intellectual property rights, Asia Law House.
2. Guru, M. & Rao, M.B. (2003) U nderstanding Trips: Managing Knowledge in Developing Countries, Sage Publications.
3. Ganguli, P. (2001) Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill.
4. Miller, A.R. & Davis, M.H. (2000) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers.
5. Watal, J. (2008) Intellectual property rights in the WTO and developing countries, Oxford University Press, New Delhi.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Pesticide Chemistry</td><td colspan="3">Course Code:
SBS CH 020406 SE 4004</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

IV</td><td>L

4</td><td>T

0</td><td colspan="2">P

0</td><td>Credits

4</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic knowledge of chemistry and pesticides</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To offer recognition as a chemist with understanding of various pesticides with respect to synthesis of pesticides, their formulations development and analysis of physico-chemical properties.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected
CO1: To learn to understand chemistry of pesticide and their formulations
CO2: They will be able to apply the fundamental knowledge of pest control methods including IPM
CO3: Gain knowledge about and various agrochemicals
CO4: Gain knowledge about botanicals and bio-pesticides
CO5: Different ways of their formulations and analysis of pesticides.</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).	15
II	**IMPORTANT EXAMPLES FROM EACH CHEMICAL CLASS** Pyrethroids – Alphamethrin, Lambda – cyhalothrin, Biphenthrin, Inorganic Compounds: Inorganic Fungicides – Sulphur, Copper Salts; Inorganic fumigant – hydrogen cyanide ; Inorganic rodenticides – Zinc phosphides; Herbicides – Imidazolinones, Dimetholin, Sulphonyl Urea, Dinitroaniline, Butachlor, Trifluralin, Auxadiazines; Organo-tin compounds.	15

III	**APPLICATIONS AND ITS ENVIRONMENTAL IMPACTS** Role of IPR in pesticides development, Pesticides formulations : Purpose ; Adjuvants; Application of formulations; Wettable and flowable powders; Emulsions; Emulsifiable concentrates; Aqueous suspension; Solution Concentrates; Dust; Aerosol; Granules; Slow release granules; Baits; Modern safer formulations verses earlier formulations, Health hazards and environmental impacts of residential pesticides.	15
IV	**PHENYL PYRAZOLE AND ITS CHEMISTRY** Phenyl pyrazole – new class of chemistry; Endosulphan; Chlopyriphos; Carbamyl; Alphamethrin, Biological control of Pests.	15

Suggested Readings:

1. Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New
2. York, 1978.
3. Thomas A. Unger, Pesticide Synthesis Handbook, Prochrom Industrias Quimicas S/A Elsevier, 1996.
4. Roberts TR, Robert, Hutson DH, Jewess PJ, editors. Metabolic pathways of agrochemicals: insecticides and fungicides. Royal Society of Chemistry; 1998.
5. S. K. Handa, Principles of Pesticide Chemistry, Ed. By Agrobios (India) ISBN 9788177542165, 2008.
6. Vyas SC. Handbook of Systemic Fungicides: Compounds. Tata McGraw-Hill; 1993.
7. Zweig G. Analytical methods for pesticides, plant growth regulators and food additives Vol. I –XVII.
8. Matolcsy G, Nádasy M, Andriska V. Pesticide chemistry. Elsevier; 1989

<table>
<tr><td>Course No:</td><td colspan="6">Course Name:
Analytical Clinical Biochemistry</td><td colspan="3">Course Code:
SBS CH 020407 SE 4004</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

IV</td><td>L

4</td><td>T

0</td><td>P

0</td><td>Credits

4</td><td colspan="3">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="8">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="8">Pre-requisite of course: Basic understanding of the structures, properties and functions of biomolecules</td></tr>
<tr><td>Course Objectives</td><td colspan="9">It will introduce the student the structure and function of biomolecules, and understand the chemical principles in life processes. Classification, disorders related to overproduction and underproduction of hormones are also emphasized in this paper</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected
CO1: To understand the structure and metabolic process
CO2: Understand biomolecules
CO3: Gain knowledge about regulation in metabolic pathways
CO4: Understand disorders of metabolic pathways</td></tr>
<tr><td colspan="10" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO CARBOHYDRATES AND LIPIDS** Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides. Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins, Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.	15
II	**PROTEINS AND ENZYMES : IMPORTANCE AND REGULATION**	15

	Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins. Enzymes: Nomenclature, classification, Characteristics (mention of Ribozymes), Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry. effect of pH, temperature on enzyme activity, enzyme inhibition.	
III	**NUCLEIC ACIDS** Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.	15
IV	**BIOCHEMISTRY OF DISEASE : A DIAGNOSTIC APPROACH BY BLOOD/URINE ANALYSIS** Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin. Urine: Collection and preservation of samples. 6. Formation of urine. Composition and estimation of constituents of normal and pathological urine.	15

Suggested Readings:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell (1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry*. Cambridge University Press (2009).
3. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons, 2010.
4. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
5. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
6. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman, 2013.

List of GE Courses To Be Offered To The Other Departments

Sr. No.	Name of the course	Course Code	L	T	P	Credits
1	GE: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	SBS CH 020101 GE 4004	4	0	0	**4**
2	GE-Lab: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	SBS CH 020102 GE 0042	0	0	4	**2**
3	GE: Chemical Energetics, Equilibria & Functional Organic Chemistry-I	SBS CH 020201 GE 4004	4	0	0	**4**
4	GE Lab: Chemical Energetics, Equilibria & Functional Organic Chemistry-I	SBS CH 020202 GE 0042	0	0	4	**2**
5	Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry-II	SBS CH 020301 GE 4004	4	0	0	**4**
6	GE Lab: Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry-II	SBS CH 020302 GE 0042	0	0	4	**2**
7	GE: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics	SBS CH 020303 GE 4004	4	0	0	**4**
8	GE Lab: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics	SBS CH 020304 GE 0042	0	0	4	**2**
9	Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra	SBS CH 020401 GE 4004	4	0	0	**4**
10	GE Lab: Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra	SBS CH 020402 GE 0042	0	0	4	**2**

11	GE: Quantum Chemistry, Spectroscopy & Photochemistry	SBS CH 020403 GE 4004	4	0	0	**4**
12	GE Lab: Quantum Chemistry, Spectroscopy & Photochemistry	SBS CH 020404 GE 0042	0	0	4	**2**
13	Molecules of Life	SBS CH 020405 GE 4004	4	0	0	**4**
14	GE Lab: Molecules of Life	SBS CH 020406 GE 0042	0	0	4	**2**
15	Chemistry of Main Group Elements, Theories of Acids & Bases	SBS CH 020407 GE 4004	4	0	0	**4**
16	GE Lab: Chemistry of Main Group Elements, Theories of Acids & Bases	SBS CH 020408 GE 0042	0	0	4	**2**

Note:

1. University/Department may include more options or delete some from this list.
2. The courses will be offered according to faculty strength and as per availability of faculty members.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons</td><td colspan="4">Course Code:
SBS CH 020101 GE 4004</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-M.Sc.</td><td>Semester:

I</td><td>L

4</td><td>T

0</td><td>P

0</td><td>Credits

4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide basic knowledge of fundamentals of inorganic chemistry and organic chemistry to the students.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: The wave function
CO2: Structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams
CO3: Importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect
CO4: The nature and behavior of organic compounds
CO5:Mechanisms of several organic reactions including free radical/electrophilic substitution/addition
CO6: The fundamental concepts of stereochemistry</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
	INORGANIC CHEMISTRY-1	
I	**ATOMIC STRUCTURE** Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.	14

	What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number(*s*) and magnetic spin quantum number (m_s). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.	
II	**CHEMICAL BONDING AND MOLECULAR STRUCTURE** **Ionic Bonding:** General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. **Covalent Bonding:** VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. **MO Approach:** Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.	16
	ORGANIC CHEMISTRY-1	
III	**FUNDAMENTALS OF ORGANIC CHEMISTRY** Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.	16

	Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. **Stereochemistry**: Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis-trans* nomenclature; CIP Rules: R/S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).	
IV	**ALIPHATIC HYDROCARBONS** Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. **Alkanes:** (Upto 5 Carbons) Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. **Alkenes:** (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. **Alkynes**: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$	14

Suggested Readings:

1. J. Singh, L.D.S. Yadav, Organic Chemistry (Volume I), 14th Edition, Pragati Prakashan, 2019.
2. T.W. Graham Solomon, C.B. Fryhle, & S.A. Dnyder, Organic Chemistry, John Wiley & Sons, 2014.
3. J.E. McMurry, Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning Edition, 2013.
4. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2nd Edition, New Age
5. International Publishers, 2010.
6. R.T. Morrison & R.N. Boyd, Organic Chemistry, Pearson, 2010.
A. Bahl, & B.S. Bahl, S. Chand, Advanced Organic Chemistry, 2010.
7. J.E. Huheey, E.A. Keiter, R.L. Keiter, & O.K. Medhi, Inorganic Chemistry: Principles of Structure and
8. Reactivity, Pearson Education India, 2006.
9. E.L. Eliel, Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
10. F.A. Cotton, G. Wilkinson, & P.L. Gaus, Basic Inorganic Chemistry, 3rd Edition, Wiley, 1995.
11. J.D. Lee, Concise Inorganic Chemistry ELBS, 1991.
12. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi 1988.
13. Cotton, F.A., Wilkinson, G. & Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition, Wiley, 1995.
14. Finar, I.L. Organic Chemistry (Volume I & II), E.L.B.S.,1988.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE-Lab: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons</td><td colspan="3">Course Code:
SBS CH 020102 GE 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc.</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="5">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="7">To inculcate the common skills required for performing simple inorganic and organic chemistry practicals.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: The estimation techniques by volumetric analysis
CO2: The handling skills of simple chemicals, glassware and small equipment.
CO3: The qualitative analysis of simple organic compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	***INORGANIC CHEMISTRY*** **VOLUMETRIC ANALYSIS** i. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. ii. Estimation of oxalic acid by titrating it with $KMnO_4$. iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$. iv. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator. v. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.	30
II	***ORGANIC CHEMISTRY*** **QUAILITATIVE ANALYSIS OF ORGANIC COMPOUNDS** i. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).	30

	ii. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given) (a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography. (b) Identify and separate the sugars present in the given mixture by paper chromatography.	

Suggested Readings:

1. G. Svehla, Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. J. Mendham, Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. A.I. Vogel, Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th Edition, 1996.
4. F.G. Mann, & B.C. Saunders, Practical Organic Chemistry Orient-Longman, 1960.

Course No:	Course Name: GE: Chemical Energetics, Equilibria & Functional Organic Chemistry-I					Course Code: SBS CH 020201 GE 4004		
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc.	**Semester:** II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:**	**04**
			4	0	0	4	**Total Hrs.:**	**60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:**			**3 Hrs.**			
		Pre-requisite of course: None						

Course Objective	*To provide basic knowledge of chemistry of aromatic hydrocarbons, alky and aryl halides, alcohols, phenols, ethers and carbonyl compounds. To provide basic understanding of chemical energetics, chemical equilibrium and ionic equilibria.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basics of chemical energetics. **CO2**: Basics of chemical equilibrium and ionic equilibria. **CO3**: Chemistry of aromatic hydrocarbons, alky and aryl halides. **CO4**: Chemistry of alcohols, phenols, ethers and carbonyl compounds.

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
	PHYSICAL CHEMISTRY-1	
I	**CHEMICAL ENERGETICS** Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.	15

II	**CHEMICAL EQUILIBRIUM AND IONIC EQUILIBRIA:** Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases. Ionic Equilibrium: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle	15
	ORGANIC CHEMISTRY-2	
III	**AROMATIC HYDROCARBONS** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). **ALKYL AND ARYL HALIDES** Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.	15
IV	**ALCOHOLS, PHENOLS AND ETHERS (UPTO 5 CARBONS)** Alcohols: *Preparation:* Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts.	15

	Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. Ethers (aliphatic and aromatic): Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.	

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
2. T.W. Graham Solomon, C.B. Fryhle, & S.A. Dnyder, Organic Chemistry, John Wiley & Sons, 2014.
3. J.E. McMurry, Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
4. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume II), 2nd Edition, New Age International Publishers, 2010.
5. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2nd Edition, New Age International Publishers, 2010.
6. I.L. Finar, Organic Chemistry (Volume I & II), E.L.B.S.
7. R.T. Morrison, & R.N. Boyd, Organic Chemistry, Pearson, 2010.
8. A. Bahl, & B.S Bahl, S. Chand, Advanced Organic Chemistry, 2010.
9. J.C. Kotz, P.M Treichel, & J.R. Townsend, General Chemistry Cengage Learning India Pvt. Ltd., New Delhi, 2009.
10. G.M. Barrow, Physical Chemistry, Tata McGraw-Hill, 2007.
11. G.W. Castellan, Physical Chemistry, 4th Edition, Narosa, 2004.
12. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, 1988.
13. B.H Mahan, University Chemistry, 3rd Edition, Narosa, 1998.
14. R.H. Petrucci, General Chemistry, 5th Edition, Macmillan Publishing Co.: New York, 1985.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE Lab: Chemical Energetics, Equilibria &
Functional Organic Chemistry-I</td><td colspan="3">Course Code:
SBS CH 020202 GE 0042</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc.</td><td>Semester:

II</td><td>L

0</td><td>T

0</td><td>P

4</td><td>Credit

2</td><td>Contact Hrs. per Week: 04
Total Hrs: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.

Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="7">To acquire the skills for handling reactions to prepare simple organic compounds. To provide knowledge about the purification techniques for organic compounds and their m.pt determination to the students. To explain the importance and applications of thermochemistry and to calculate the pH of the different solutions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Thermochemistry and its applications in chemistry
CO2: Ionic equilibria and measurement of pH of different solutions.
CO3: Purification techniques and their importance
CO4: Single-step organic preparations and purification of the obtained product</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**PHYSICAL CHEMISTRY** **Thermochemistry** 1. Determination of heat capacity of calorimeter for different volumes. 2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. 3. Determination of enthalpy of ionization of acetic acid. 4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl). 5. Determination of enthalpy of hydration of copper sulphate. 6. Study of the solubility of benzoic acid in water and determination of ΔH. **Ionic equilibria** pH measurements Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter. a) Preparation of buffer solutions:	30

	(i) Sodium acetate-acetic acid (ii)Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.	
II	**ORGANIC CHEMISTRY** 1. Purification of organic compounds by crystallization (from water and alcohol) and distillation. 2. Criteria of Purity: Determination of melting and boiling points. 3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done. (a) Bromination of Phenol/Aniline (b) Benzoylation of amines/phenols (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone	30

Suggested Readings:

1. B.D. Khosla ; V . C . Garg & A. Gulati Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. A.L. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford & P.W.G. Smith Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
3. F.G. Mann & B.C. Saunders Practical Organic Chemistry Orient-Longman, 1960.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Solutions, Phase Equilibria, Conductance, Electrochemistry & Functional Group Organic Chemistry-Ii</td><td colspan="3">Course Code:
SBS CH 020301 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of solutions, phase equilibria, basic organic reactions.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of different types of binary solutions, phase equilibria, conductance, and organic reactions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Explain the concepts of different types of binary solutions-miscible, partially miscible and immiscible along with their applications
CO2: Explain the thermodynamic aspects of equilibria between phases and draw phase diagrams of simple one component and two component systems
CO3: Explain the factors that affect conductance, migration of ions and application of conductance measurement
CO4: Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements
CO5: Understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses
CO6: Design newer synthetic routes for various organic compounds</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**SOLUTIONS AND PHASE EQUILIBRIA** **Solutions** Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-	**15**

	composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. **Phase Equilibria** Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).	
II	**CONDUCTANCE AND ELECTROCHEMISTRY** **Conductance** Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid- base). **Electrochemistry** Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).	**15**
III	**CARBOXYLIC ACIDS AND THEIR DERIVATIVES, AMINES AND DIAZONIUM SALTS** **Carboxylic acids and their derivatives** Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.	**15**

	Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. **Amines and Diazonium Salts** Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.	
IV	**AMINO ACIDS, PEPTIDES AND PROTEINS, AND CARBOHYDRATES** **Amino Acids, Peptides and Proteins** Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C- activating groups and Merrifield solid-phase synthesis. **Carbohydrates** Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.	**15**

Suggested Readings:

1. Barrow, G. M. *Physical Chemistry* Tata McGraw-Hill (2007).
2. Castellan, G. W. *Physical Chemistry* 4^{th} Ed. Narosa (2004).
3. Kotz, J. C., Treichel, P. M. & Townsend, J. R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B. H. *University Chemistry*, 3^{rd} Ed. Narosa (1998).
5. Petrucci, R.H. *General Chemistry*, 5^{th} Ed., Macmillan Publishing Co.: New York (1985).
6. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7^{th} Ed.*, W. H. Freeman.
10. Berg, J. M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE Lab: Solutions, Phase Equilibria, Conductance, Electrochemistry & Functional Group Organic Chemistry-Ii</td><td colspan="4">Course Code:
SBS CH 020302 GE 0042</td></tr>
<tr><td rowspan="2">Batch:
2021 Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Determine distribution constant
CO2: Determine conductance
CO3: Understand potentiometric titrations
CO4: Determine qualitative organic analysis</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

<table>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>PHYSICAL CHEMISTRY

Distribution
Study of the equilibrium of one of the following reactions by the distribution method:
$I2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$

$Cu^{2+}(aq) + xNH_2(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria
a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves
b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it
c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.</td><td>30</td></tr>
</table>

	Conductance (i) Determination of cell constant (ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid (iii) Perform the following conductometric titrations: (a) Strong acid vs. strong base and (b) Weak acid vs. strong base **Potentiometry** (i) Perform the following potentiometric titrations: (ii) Strong acid vs. strong base (iii) Weak acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt	
II	**ORGANIC CHEMISTRY** **I** Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative. **II** (i) Separation of amino acids by paper chromatography (ii) Determination of the concentration of glycine solution by formylation method (iii) Titration curve of glycine (iv) Action of salivary amylase on starch (v) Effect of temperature on the action of salivary amylase on starch (vi) Differentiation between a reducing and a nonreducing sugar	30

Suggested Readings:

1. Vogel, A. I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J.; Smith, P. W. G. *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th ed, 1996.
2. Mann, F. G.; Saunders, B. C. *Practical Organic Chemistry* Orient-Longman, 1960.
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V. K.; Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press (2004)

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics</td><td colspan="3">Course Code:
SBS CH 020303 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2021 Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand chemistry of d and f block elements
CO2: Properties of coordination compounds
CO3: Understanding VBT for bonding in coordination compounds
CO4: Understanding CFT for bonding in coordination compounds
CO5: Understand the real gases deviation from ideal behaviour
CO6: Define rate of reactions and the factors that affect the rates of chemical reactions.</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**TRANSITION ELEMENTS (3d SERIES)** General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).	**15**

II	**COORDINATION CHEMISTRY** Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. **CRYSTAL FIELD THEORY** Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.	**15**
III	**KINETIC THEORY OF GASES** Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).	**15**
IV	**CHEMICAL KINETICS** The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).	**15**

Suggested Readings:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill, 2007.
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa, 2004.
3. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
4. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York, 1985.
5. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.
6. Atkins, P. Paula, J. Atkins' Physical Chemistry, 10th Edition. Oxford University Press, 2014.

Course No:	Course Name:	Course Code:
	GE Lab: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics	SBS CH 020304 GE 0042

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2021 Onwards	Integrated B.Sc.-M.Sc. Chemistry	III	0	0	4	2	**Total Hrs: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.
Course Objective	*To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Analyze presence of acid and basic radicals **CO2**: Determine hardness of water **CO3:** Study reaction rates **CO4:** Measurement of surface tension and viscosity

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC CHEMISTRY** Semi-micro qualitative analysis (using H_2S or other methods) of mixtures - not more than two ionic species (one anion and one cation, excluding insoluble salts) out of the following: Cations : NH^{4+}, Pb^{2+}, B^{i3+}, Cu^{2+}, Cd^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+} Anions : CO_3^{2-} , S^{2-}, SO_2^{-}, $S_2O_3^{2-}$, NO^{3-}, CH_3COO^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3 , SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-} (Spot tests should be carried out wherever feasible) 1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically. 2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.	30
II	**PHYSICAL CHEMISTRY** (I) Surface tension measurement (use of organic solvents excluded).	30

	a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer. b) Study of the variation of surface tension of a detergent solution with concentration. (II) Viscosity measurement (use of organic solvents excluded). a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer. b) Study of the variation of viscosity of an aqueous solution with concentration of solute. (III) Chemical Kinetics Study the kinetics of the following reactions. 1. Initial rate method: Iodide-persulphate reaction 2. Integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid. 3. Saponification of ethyl acetate.	

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

Course No:	Course Name: GE: Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy						Course Code: SBS CH 020401 GE 4004
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			4	0	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration: 3 Hrs.** **Pre-requisite of course:** Basic understanding of 3*d* elements, bonding aspects in organometallic compounds along with some spectroscopic parameters.
Course Objective	*To provide students with basic concept of bonding aspects in organometallic/bioinorganic/polynuclear compounds.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Understand the chemistry and applications of 3d elements including their oxidation states and important properties of the familiar compounds potassium dichromate, potassium permanganate and potassium ferrocyanide **CO2**: Use IR data to explain the extent of back bonding in carbonyl complexes **CO3**: Get a general idea about role of metal ions present in biological systems **CO4:** Understand the fundamentals of functional group chemistry, polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism **CO5:** Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques **CO6:** Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CHEMISTRY OF 3*d* METALS AND ORGANOMETALLIC COMPOUNDS** **Chemistry of 3*d* metals** Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties);	**15**

	Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$. **Organometallic Compounds** Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).	
II	**BIO-INORGANIC CHEMISTRY** A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).	**15**
III	**POLYNUCLEAR AND HETERONUCLEAR AROMATIC COMPOUNDS AND ACTIVE METHYLENE COMPOUNDS** **Polynuclear/heteronuclear aromatic compounds** Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. **Active methylene compounds:** *Preparation:* Claisen ester condensation. Keto-enol tautomerism. *Reactions:* Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).	**15**
IV	**APPLICATION OF SPECTROSCOPY TO SIMPLE ORGANIC MOLECULES** Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α,β – unsaturated compounds.	**15**

	Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).	

Suggested Readings:

1. Huheey, J. E.; Keiter, E.; Keiter, R. *Inorganic Chemistry: Principles of Structure and Reactivity,* Pearson Publication.
2. Miessler, G. L.; Tarr, D. A. *Inorganic Chemistry,* Pearson Publication.
3. Lee, J. D. *A New Concise Inorganic Chemistry,* E.L.B.S.
4. Cotton, F. A.; Wilkinson, G. *Basic Inorganic Chemistry*, John Wiley & Sons.
5. Finar, I. L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
6. Dyer, J. A. *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.
7. Silverstein, R. M.; Bassler, G. C.; Morrill, T. C. *Spectroscopic Identification of Organic Compounds*, John Wiley & Sons.
8. Morrison, R. T.; Boyd, R. N. *Organic Chemistry,* Prentice Hall.
9. Sykes, P. *A Guide Book to Mechanism* in *Organic Chemistry,* Orient Longman.
10. Bahl, A.; Bahl, B. S. *Advanced Organic Chemistry,* S. Chand.

Course No:	Course Name: GE Lab: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY						Course Code: SBS CH 020402 GE 4004
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
		III	0	0	4	2	**Total Hrs: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic understanding of metal-carbon bonds, metal ions in biology, hydrocarbons and spectroscopy.
Course Objective	*To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various spectroscopic techniques.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of metal-carbon bond in chemistry **CO2**: Importance of metal ions in biology **CO3:** Understanding of enzymes and proteins **CO4:** Synthesis of simple molecules **CO5:** And their characterizations by UV and IR spectroscopy

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC CHEMISTRY** 1. Separation of mixtures by chromatography: Measure the Rf value in each case. (Combination of two ions to be given) Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+} 2. Preparation of any two of the following complexes and measurement of their conductivity: a. tetraamminecarbonatocobalt (III) nitrate b. tetraamminecopper (II) sulphate c. potassium trioxalatoferrate (III) trihydrate Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.	30
II	**ORGANIC CHEMISTRY**	30

	Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative. Characterization by UV and IR spectroscopy.	

Suggested Readings:

1. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

Course No:	Course Name: GE: Quantum Chemistry, Spectroscopy & Photochemistry						Course Code: SBS CH 020403 GE 4004
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			4	0	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration: 3 Hrs.** **Pre-requisite of course:** Basic understanding of quantum mechanics, molecular spectroscopy and photochemical reactions.
Course Objective	*To provide students with basic concept of quantum mechanics, bonding in molecules, electronic transition, quantum efficiency and photochemical processes.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions **CO2**: Understand chemical bonding in molecules **CO3**: Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra **CO4:** Understand the fundamentals of electron spin resonance **CO5:** Understanding fundamental of photophysical phenomena **CO6:** Define rate of reactions and the factors that affect the rates of chemical reactions.

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**QUANTUM CHEMISTRY** Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.	**15**

	Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.	
II	**CHEMICAL BONDING** Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H^{2+}. Bonding and antibonding orbitals. Qualitative extension to H2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH2 type molecules.	**15**
III	**MOLECULAR SPECTROSCOPY** Interaction of electromagnetic radiation with molecules and various types of spectra; Born- Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.	**15**

	Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.	
IV	**PHOTOCHEMISTRY** Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.	**15**

Suggested Readings:

1. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi, 2006.
2. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill, 2001.
3. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA, 2004.
4. Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press, 2005.
5. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press, 2015.
6. Rohatgi, K. K. Mukherjee, K. K. Fundamentals of Photochemistry, 3rd Edition. New Age International (P) Ltd., 2014.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE Lab: Quantum Chemistry, Spectroscopy & Photochemistry</td><td colspan="4">Course Code:
SBS CH 020404 GE 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of spectroscopy and colourimetry</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of quantum mechanics, bonding in molecules, electronic transition, quantum efficiency and photochemical processes.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions
CO2: Understand chemical bonding in molecules
CO3: Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra
CO4: Understand the fundamentals of electron spin resonance
CO5: Understanding fundamental of photophysical phenomena
CO6: Define rate of reactions and the factors that affect the rates of chemical reactions.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">UV/VISIBLE SPECTROSCOPY
i) Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
ii) Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
iii) Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.</td><td>30</td></tr>
<tr><td>II</td><td colspan="6">COLOURIMETRY
i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7$ in a solution of unknown concentration
ii) Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.</td><td>30</td></tr>
</table>

	iii) Study the kinetics of iodination of propanone in acidic medium. iv) Determine the amount of iron present in a sample using 1,10-phenathroline. v) Determine the dissociation constant of an indicator (phenolphthalein). vi) Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide. vii) Analyse the given vibration-rotation spectrum of HCl(g)	

Suggested Readings:

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE: Molecules of Life</td><td colspan="5">Course Code:
SBS CH 020405 GE 4004</td></tr>
<tr><td>Batch:
2021
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

IV</td><td>L
4</td><td>T
0</td><td>P
0</td><td>Credit
4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.

Pre-requisite of course: Basic understanding of biological processes.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide students with basic concept of biological processes and energy in biosystem.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses
CO2: Gain an insight into mechanism of enzyme action and inhibition
CO3: Understand the basic principles of drug-receptor interaction and SAR
CO4: Understand biological processes like replication, transcription and translation
CO5: Demonstrate an understanding of metabolic pathways, their inter-relationship, regulation and energy production from biochemical processes
CO6: To understand concept of energy in biosystems</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CARBOHYDRATES** Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.	**15**

II	**AMINO ACIDS, PEPTIDES AND PROTEINS** Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t- butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.	**15**
III	**ENZYMES AND CORRELATION WITH DRUG ACTION, AND NUCLEIC ACIDS** **Enzymes and correlation with drug action** Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non- competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure-activity relationships of drug molecules, binding role of –OH group,-NH_2 group, double bond and aromatic ring. **Nucleic Acids** Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (**nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.	**15**
IV	**LIPIDS AND CONCEPT OF ENERGY IN BIOSYSTEMS** **Lipids** Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). **Concept of Energy in Biosystems** Calorific value of food. Standard caloric content of carbohydrates, proteins and fats.	**15**

	Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate-Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.	

Suggested Readings:

1. Morrison, R. T.; Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L.; Cox, M. M. *Lehninger's Principles of Biochemistry* 7^{th} *Ed.,* W. H. Freeman.
5. Berg, J. M. Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

Course No:	**Course Name:** GE Lab: Molecules of Life				**Course Code:** SBS CH 020406 GE 0042		
Batch: 2021 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week: 04** **Total Hrs: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks		**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic understanding of paper chromatography, saponification value, titration, synthesis and Extraction of DNA from onion/cauliflower.					
Course Objective	*To provide students with basic concept of synthesis of medicinal compounds and paper chromatography. Also determination of saponification/concentration of some given sample.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** To understand paper chromatography in separation of amino acids **CO2**: Determine saponification value **CO3:** To understand extraction of DNA **CO4:** Synthesis of some medicinal compounds						

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	**Contents**	**Contact Hrs.**
I	**INORGANIC CHEMISTRY** 1. Separation of amino acids by paper chromatography 2. To determine the concentration of glycine solution by formylation method. 3. Study of titration curve of glycine 4. Action of salivary amylase on starch 5. Effect of temperature on the action of salivary amylase on starch.	30
II	**ORGANIC CHEMISTRY** 1. To determine the saponification value of an oil/fat. 2. To determine the iodine value of an oil/fat 3. Differentiate between a reducing/nonreducing sugar. 4. Extraction of DNA from onion/cauliflower 5. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.	30

Suggested Readings:

1. Furniss, B. S.; Hannaford, A. J.; Rogers, V.; Smith, P. W. G.; Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
2. Ahluwalia, V. K.; Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

Course No:	Course Name: GE: Chemistry of Main Group Elements, Theories of Acids and Bases	Course Code: SBS CH 020407 GE 4004

Batch:	Programme:	Semester:	L	T	P	Credit	Contact Hrs. per Week: 04
2021 Onwards	Integrated B.Sc.-M.Sc. Chemistry	IV	4	0	0	4	Total Hours: 60

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** Basic properties of acid-base and *s*/*p*-block elements.
Course Objective	*To provide students with basic concept of* periodic properties and bonding aspects in molecules.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: To understand acid base interaction **CO2**: Gain an insight into metallurgical processes **CO3**: To understand the basic principles of periodic properties of *s*/*p*-block elements **CO4:** To understand multicentre bonding in boranes **CO5:** Understanding of inorganic polymers **CO6:** To understand concept of pseudohalides

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ACIDS AND BASES, GENERAL PRINCIPLES OF METALLURGY** **Acids and Bases** Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.	15

	General Principles of Metallurgy Chief modes of occurrence of metals based on standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents. Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process.	
II	***s*- AND *p*-BLOCK ELEMENTS** Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling scale). General characteristics of *s*-block metals like density, melting and boiling points, flame colour and reducing nature. Oxidation states of *s*- and *p*-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy in C, P and S. Complex forming tendency of *s* block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals. Solutions of alkali metals in liquid ammonia and their properties. Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of *s*-block metals.	**15**
III	**Structure, bonding and properties** Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH3), 14, 15, 16 and 17. Oxides of N and P, Oxoacids of P, S and Cl. Halides and oxohalides of P and S (PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2), Interhalogen compounds. A brief idea of pseudohalides	**15**
IV	**NOBLE GASES AND INORGANIC POLYMERS** **Noble gases** Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6 ,bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory. **Inorganic Polymers**	**15**

	Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in $(NPCl_2)_3$.	

Suggested Readings:

1. Lee, J. D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F. A.; Wilkinson, G.; Gaus, P. L. *Basic Inorganic Chemistry*, 3rd ed. Wiley.
3. Douglas, B. E.; McDaniel, D. H.; Alexander, J. J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Greenwood, N. N.; Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
5. Rodger, G. E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L.; Tarr, D. A. *Inorganic Chemistry* 4th Ed. Pearson, 2010.
7. Atkin, P.; *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press 2010.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE Lab: Chemistry of Main Group Elements, Theories of Acids and Bases</td><td colspan="4">Course Code:
SBS CH 020408 GE 0042</td></tr>
<tr><td rowspan="2">Batch:
2021
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of quantitative analysis and synthesis of some inorganic complexes.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of iodometric estimation, gravimetric estimation and determination of dissolved oxygen in water sample.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand iodometric estimation
CO2: To understand gravimetric estimation
CO3: Determination of dissolved oxygen in water samples
CO4: Synthesis of some inorganic complexes</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC CHEMISTRY** 1.Iodometric estimation of potassium dichromate and copper sulphate 2.Iodimetric estimation of antimony in tartaremetic 3.Estimation of amount of available chlorine in bleaching powder and household bleaches 4. Estimation of iodine in iodized salts. 5. Iodimetric estimation of ascorbic acid in fruit juices.	30
II	**ORGANIC CHEMISTRY** 1. Estimation of dissolved oxygen in water samples. 2. Gravimetric estimation of sulphate as barium sulphate. 3. Gravimetric estimation of aluminium as oximato complex 4. Preparation of the following: potash alum, chrome alum, tetraamminecopper(II) sulphate monohydrate, potassium trioxalatoferrate(III) (any two, including one double salt and one complex).	30

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

9. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning
- Hands on training
- Self study analysis
- Report writing

10. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- Student-Centric Pedagogical Approach focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, may be adopted

11. ASSESSMENT AND EVALUATION

Overall assessment will be made as per relevant ordinances of CUH.

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired if required
- Group Examinations on Problem solving exercises

- Seminar Presentations
- Review of Literature

Collaborative Assignments

13. REFERENCES

Instructional Template for Facilitating Implementation of Choice Based Credit System (CBCS) (https://www.ugc.ac.in/pdfnews/4426331_Instructional-Template.pdf)

Scheme and Syllabi of B. Sc. Honours with chemistry

(https://www.ugc.ac.in/pdfnews/6573215_B.Sc.HONOURS-CHEMISTRY.pdf**)**

Scheme and Syllabi of B. Sc. with chemistry

(https://www.ugc.ac.in/pdfnews/0614691_LOCF-chemistry.pdf)

National Education Policy-2020.

https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

The draft subject specific LOCF templates available on UGC website.

https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==

Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website.

https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions (https://www.ugc.ac.in/e-book/GL%20Multipe%20Entry%20Exit/mobile/index.html)

14. APPENDICES

Curricular Reforms — Extracts from National Education Policy-2020

CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi

Of

Integrated B.Sc.-M.Sc. (Chemistry)

(w.e.f. Session 2022-23)

DEPARTMENT OF CHEMISTRY
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	
Approval Date :	06-09-2022	12-09-2022	

Table of Contents

VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a world-class teaching and research reputation of the department that contributes to society through its innovative, creative and scholarly approach.

Mission

To educate the students by adopting highest academic and professional standards to meet the global competency in the field of chemical sciences. To establish and maintain a high quality of support, research facilities, multidisciplinary and skill-based learning opportunities to our staff, students and researchers to orient them to world class creative and innovative minds.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in the 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About Chemistry

Chemistry is the science of matter and its transformations. It addresses fundamental questions about the observable matter, ranging from its components, structure, properties and interconversions. As a system of knowledge, Chemistry not only explains the existence and behavior of matter around and within us, but also empowers us to manipulate the matter into new and improved forms for our use. From the ancient practices of rasayan vidya and alchemy, modern chemistry has grown over centuries into a formidable science that touches all aspects of human life. Humanity's progress in the last three centuries is pivoted on the contributions of chemistry, chemical industry and associated endeavors. The range of influence of chemistry in our life spans from essentials such as food (agrochemicals, preservatives), shelter (cement, metals, alloys, polymers) and health (drugs, cosmetics, soap, toothpaste), to advancements such as textiles (polymers, leather), beverages (flavoring and fermentation), crime fighting (forensics), weaponry (explosives), space travel (fuel) and cosmology (element detection). The list can go on endlessly. The most visible contribution of chemistry to civilization is achieved by the advancements in modern medicine that was fuelled by organic chemistry. This led to significant improvements in the living standards, extension of human average life span and fighting of dangerous diseases such as cancer and microbial infections.

Chemistry is placed centrally between the other two major branches of science, namely physics and biology. Therefore, it is often called the *central science*. It influences the developments in these two broad realms of science as much as it is influenced by the discoveries in them. The fundamental importance of chemistry and chemical industry in sustaining human civilization demands for a steady supply of trained and skilled manpower. Thus, it is unsurprising that it is an essential and integral department in higher education institutions.

Education in chemistry not only imparts the technical know-how about structure, reactions and properties of matter, but also empowers the learner to raise fundamental questions about various natural phenomena, address local issues and come up with sustainable solutions, identify areas of life where intervention of chemistry can bring about progress and imbibe and spread the spirit of free enquiry and scientific temper.

iii) About the Programme (Nature, Extent and Aims)

The integrated B.Sc.-M.Sc. Programme in Chemistry will impart advanced knowledge of basic and applied chemical sciences to the graduates. It will prepare the students for taking up challenging assignments in academia and industry and also empower them with skill and knowledge for generating employment for their own and others. The Programme introduces the students to advanced developments in chemical sciences as well as in the field of other allied sciences, by providing them multidisciplinary and interdisciplinary courses. The design of choice-based curriculum can enrich students with analytical and problem-solving capabilities. It is designed to bring out the best of the abilities of each student, allow them to sharpen the scientific temper and be abreast with the contemporary developments in the area.

The programme includes a balanced combination of *Core*, *Elective* and *Ability Enhancement* Courses. The courses are designed in such a way to cover the entire spectrum of chemical sciences from fundamentals (that will bring admitted students from various backgrounds to a common level) to most recent advancements in the field (that will make them ready to take up challenging assignments in the real world).

The integrated B.Sc.-M.Sc. Programme in Chemistry is of a five-year duration which is divided into ten semesters. The teaching and learning in the Programme will involve theory (lectures), practicals, tutorial and seminar-based classes. During the whole programme about 40 % syllabus of each course may be delivered via online mode and with a blended teaching-learning approach.

The curriculum will be taught through formal lectures with the aid of pre-made presentations, audio and video tools whenever necessary. Other teaching aids can also be used as and when required. The additional requirements like industrial visits, summer training and project work are also incorporated into the curriculum.

The Aims of the programme include

- To inculcate basic to advanced knowledge of chemical sciences among students.
- To provide higher education, disciplinary and inter/multi-disciplinary research-oriented knowledge to the students to make them lifelong learners.
- To provide a learned, skilled and creative pool of graduates who are ready to take up challenging assignments in different kinds of chemical industries, research institutions and academia.
- To mould responsible, proactive citizens who are equipped with scientific thinking and skills to address problems of their locality
- Adequate blend of theory, computation and hands-on experiments.
- Modernized lab courses – close to recent/current research.

iv) Qualification Descriptors (possible career pathways)

On successful completion of the Integrated B.Sc.-M.Sc. Chemistry Programme, students of the department are expected to be ready to take up opportunities all around the world in areas that demand skills in chemical and allied sciences. As the chemical industry is enormously vast and diverse, numerous opportunities and challenges await the graduates. The graduates are expected to satisfactorily address the professional expectations, maintain a work-life balance and lead productive and meaningful lives. Some of the possible career paths for the undergraduate and postgraduate students may be:

1. Teaching and Research in academia

2. Research scientists in pharmaceutical and other chemical and material industries

3. Research scientists in other allied sciences

4. Entrepreneurship in chemical science-based ventures

5. Administrative Assignments in various government and private agencies

6. Chemist/Scientist/Technician assignments in any of the following industries: pharmaceutical, polymers, petrochemicals, materials sciences, nanotechnology, fuels, non-conventional energy, renewable resources, agrochemicals, fermentation and processing, paints and pigments, metallurgy, packaging, cosmetics, cements, natural products, forensics, explosives, and any other various allied branches of chemistry.

2. STRUCTURE OF INTEGRATED B.Sc.-M.Sc. PROGRAMME

The Integrated B.Sc.-M.Sc. Chemistry Programme is of a *five-year* duration which is divided into ten semesters. The programme under Choice-Based Credit System (CBCS) includes a balanced combination of *Core*, *Elective* and *Ability Enhancement Courses* (Compulsory and Skill based). Distribution of the courses for undergraduate programme (for first three years) is given in **Table-1**.

The programme offers exit options to the students as per the relevant ordinances of CUH and guidelines of UGC and Ministry of Education.

After successful completion of five years (ten semesters) of the programme the candidate will be awarded with the Integrated Degree i.e. **Integrated B.Sc.-M.Sc. (Chemistry)**.

Table 1 (% age of courses for first three years of the Programme)

Sr. No.	Types of Courses	Nature	Total Credit	Credit % age of Courses	% age of Courses
1	**Core Courses (CC)**	Compulsory Courses (CC)	84	56.75	53.85
2	**Elective Courses (EC)**	Discipline Specific Elective Courses (DSE)	24	16.21	15.38
		Generic Elective Courses (GE)	24	16.21	15.38
3	**Ability Enhancement Courses (AEC)**	Ability Enhancement Compulsory Courses (AEC)	8	5.40	7.69
		Ability Enhancement Elective (Skill Based) (SEC)	8	5.40	7.69
			148	**100**	**100**

Course Structure (Chemistry Major)

Details of courses for first three years

Courses	**Credits*** Theory+ Practical	**Credits*** Theory + Tutorial
I. Core Course (14 Papers) **Core Course Practical / Tutorial*** (14 Papers)	14×4 = 56 14×2 = 28	14×5 = 70 14×1= 14
II. Elective Course (8 Papers) A.1. Discipline Specific Elective **(4 Papers)** A.2. Discipline Specific Elective Practical/Tutorial* **(4 Papers)**	 4×4 = 16 4×2 = 08	 4×5 = 20 4×1 = 04
B.1. Generic Elective/Interdisciplinary **(4 Papers)** B.2. Generic Elective Practical/ Tutorial* **(4 Papers)**	4×4 = 16 4×2 = 08	4×5 = 20 4×1 = 04
Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester		
III. Ability Enhancement Courses **1. Ability Enhancement Compulsory**** **(2 Papers of 4 credit each)** Environmental Science/ English/ MIL Communication/Sanskrit	2×4 = 08	2×4 = 08
2. Ability Enhancement Elective (Skill Based) (Minimum 2) **(2 Papers of 4 credit each)**	2×4 = 08	2×4 = 08
Total credit	**148**	**148**

University should evolve a system/policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.
***Wherever there is a practical there will be no tutorial and vice-versa.,**
**** University/Department may include more options or delete some from this list. The courses will be offered according to faculty strength and as per availability of faculty members.**

NOTE: MOOC courses (SWAYAM) having similarity more than 75% with the core course may be offered to the students. For elective courses (whatever nomenclature may be used), the students may opt from the MOOC courses provided these courses are not in the list of core course (SWAYAM) keeps changing, the departmental committee is authorized to finalize the list of MOOC courses for each semester based on the above criteria.

3. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

(*for first three years*)

First Year

Sr. No.	Course No.	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester I								
1		Inorganic Chemistry-I	SBS CH 020101 C 3104	CC	3	1	0	4
2		Inorganic Chemistry Practical-I	SBS CH 020102 C 0042	CC	0	0	4	2
3		Organic Chemistry-I	SBS CH 020103 C 3104	CC	3	1	0	4
4		Organic Chemistry Practical-I	SBS CH 020104 C 0042	CC	0	0	4	2
5		From the list of courses available (any one)	**AEC-1**		3	1	0	4
6		From the list of courses available (any one)	**SEC-1**		2	0	0	2
7		Offered by other Departments	**GE**		3	1	4	6
					Total Credit 24			
Semester II								
1		Physical Chemistry-I	SBS CH 020201 C 3104	CC	3	1	0	4
2		Physical Chemistry Practical-I	SBS CH 020202 C 0042	CC	0	0	4	2
3		Organic Chemistry-II	SBS CH 020203 C 3104	CC	3	1	0	4
4		Organic Chemistry Practical-II	SBS CH 020204 C 0042	CC	0	0	4	2
5		From the list of courses available (any one)	**AEC-2**		3	1	0	4
6		From the list of courses available (any one)	**SEC-2**		2	0	0	2
7		(Offered by other Departments	**GE**		3	1	4	6
					Total Credit 24			

CC = Core Course; AEC = Ability Enhancement Course; SEC = Skill Enhancement Course; GE = Generic Elective Course; (or students may choose any one from the given list)

In addition to the courses students will be trained for Seminars, Group Discussions and Individual/Team Projects throughout the semesters.

Second Year

Sr. No.	Course No.	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester III								
1		Physical Chemistry-II	SBS CH 020301 C 3104	CC	3	1	0	4
2		Physical Chemistry Practical-II	SBS CH 020302 C 0042	CC	0	0	4	2
3		Organic Chemistry-III	SBS CH 020303 C 3104	CC	3	1	0	4
4		Organic Chemistry Practical-III	SBS CH 020304 C 0042	CC	0	0	4	2
5		Molecular Spectroscopy and Photochemistry	SBS CH 020305 C 3104	CC	3	1	0	4
6		Spectroscopy Practical	SBS CH 020306 C 0042	CC	0	0	4	2
7		Offered by other Departments	GE		3	1	4	6
					Total Credit 24			
Semester IV								
1		Physical Chemistry-III	SBS CH 020401 C 3104	CC	3	1	0	4
2		Physical Chemistry Practical-III	SBS CH 020402 C 0042	CC	0	0	4	2
3		Inorganic Chemistry-II	SBS CH 020403 C 3104	CC	3	1	0	4
4		Inorganic Chemistry Practical-II	SBS CH 020404 C 0042	CC	0	0	4	2
5		Introduction to Quantum Chemistry	SBS CH 020405 C 3104	CC	3	1	0	4
6		Quantum Chemistry Practical	SBS CH 020406 C 0042	CC	0	0	4	2
7		Offered by other Departments	GE		3	1	4	6
					Total Credit 24			

CC = Core Course; AEC = Ability Enhancement Course; SEC = Skill Enhancement Course; GE = Generic Elective Course; (or students may choose any one from the given list)

In addition to the courses students will be trained for Seminars, Group Discussions and Individual/Team Projects throughout the semesters.

Third Year

Sr. No.	Course No.	Course Name	Course Code	Course Type (Opted)	L	T	P	Credit
					Hrs.			
Semester V								
1		Inorganic Chemistry-III	SBS CH 020501 C 3104	CC	3	1	0	4
2		Inorganic Chemistry Practical-III	SBS CH 020502 C 0042	CC	0	0	4	2
3		Analytical Chemistry	SBS CH 020503 C 3104	CC	3	1	0	4
4		Analytical Chemistry Practical	SBS CH 020504 C 0042	CC	0	0	4	2
5		From the list of courses available	**SEC-3**		2	0	0	2
6		From the list of courses available	**DSE-1**		3	1	0	4
7		From the list of courses available	**Practical (DSE-1)**		0	0	4	2
8		From the list of courses available	**DSE-2**		3	1	0	4
9		From the list of courses available	**Practical (DSE-2)**		0	0	4	2
					Total Credit 26			
Semester VI								
1		Green Chemistry	SBS CH 020601 C 3104	CC	3	1	0	4
2		Green Chemistry Practical	SBS CH 020602 C 0042	CC	0	0	4	2
3		Materials Chemistry	SBS CH 020603 C 3104	CC	3	1	0	4
4		Materials Chemistry Practical	SBS CH 020604 C 0042	CC	0	0	4	2
5		From the list of courses available	**SEC-4**		2	0	0	2
6		From the list of courses available	**DSE-3**		3	1	0	4
7		From the list of courses available	**Practical (DSE-3)**		0	0	4	2
8		From the list of courses available	**DSE-4**		3	1	0	4
9		From the list of courses available	**Practical (DSE-4)**		0	0	4	2
					Total Credit 26			

CC = Core Course; SEC = Skill Enhancement Course; DSE = Discipline Specific Elective Course; (or students may choose any one from the given list)

In addition to the courses students will be trained for Seminars, Group Discussions and Individual/Team Projects throughout the semesters.

Note:

1. AEC, SEC, DSE and GE courses will be offered according to faculty strength and as per the availability of faculty members.
2. The University/Department may add/delete courses from time to time as per requirement.
3. The entry and exit in the Integrated B.Sc.-M.Sc. programme will be decided according the relevant University Ordinance.

LIST of COURSES

Core Papers (C): (Credit: 06 each) (3 periods + 1 tutorial/week for theory and 4 periods/week for practical)

1. Inorganic Chemistry I (4 + 4)
2. Organic Chemistry I (4 + 4)
3. Physical Chemistry I (4 + 4)
4. Organic Chemistry II (4 + 4)
5. Physical Chemistry II (4 + 4)
6. Organic Chemistry III (4 + 4)
7. Molecular Spectroscopy and Photochemistry (4+4)
8. Physical Chemistry III (4 + 4)
9. Inorganic Chemistry II (4 + 4)
10. Introduction to Quantum Chemistry (4 + 4)
11. Inorganic Chemistry III (4 + 4)
12. Analytical Chemistry (4 + 4)
13. Green Chemistry (4 + 4)
14. Materials Chemistry (4 + 4)

Discipline Specific Elective (DSE) Papers: (Credit: 06 each) (3 periods + 1 tutorial/week for theory and 4 periods/week for practical)

1. Medicinal Chemistry
2. Electrochemistry
3. Electrochemistry Practical
4. Advanced Analytical Chemistry
5. Organic Spectroscopy
6. Heterocyclic Chemistry
7. Organometallics and Bioinorganic chemistry
8. Introduction to Nanochemistry & applications
9. Dissertation (To be taken as optional in place of one DSE course)

Ability Enhancement (AEC) Papers: (Credit: 04 each) (3 periods + 1 tutorial/week)

1. English for Communication
2. History of Indian Science
3. Good Laboratory Practices
4. Cheminformatics
5. Research methodology
6. Chemistry in Everyday life

Skill Enhancement (SEC) Papers: (Credit: 02 each) (2 periods week)

1. Personality Development
2. Computer Applications in Chemistry
3. Science Communication and
4. Popularization
5. Biofertilizer
6. Herbal Science & Technology
7. Fermentation Science & Technology
8. Environment Impact Analysis

Generic Elective (GE) Papers: (Credit: 06 each) (3 periods + 1 tutorial/week for theory and 4 periods/week for practical)

1. GE: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
2. GE: Chemical Energetics, Equilibria & Functional Organic Chemistry-I
3. Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry
4. GE: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics
5. Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra
6. GE: Quantum Chemistry, Spectroscopy & Photochemistry
7. Molecules of Life
8. Chemistry of Main Group Elements, Theories of Acids & Bases

Note:

1. University/Department may include more options or delete some from this list.
2. The courses will be offered according to faculty strength and as per availability of faculty members.

4. COURSES

Semester I

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Inorganic Chemistry-I</td><td colspan="3">Course Code:
SBS CH 020101 C 3104</td></tr>
<tr><td>Batch:
2022 onwards</td><td>Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td>Semester:
I</td><td>L
3</td><td>T
1</td><td>P
0</td><td>Credits
4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.
Pre-requisite of course: Basic knowledge about atomic structure, chemical bonding, periodic properties and redox reactions.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide basic knowledge about atomic structure, quantum mechanics, dual nature of particles, bonding aspect, electrode potential etc.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding about wave function
CO2: Understand the periodicity in atomic and ionic radii, electronegativity, ionization energy, electron affinity of elements of the periodic table
CO3: Understand the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect.
CO4: In-depth knowledge about standard electrode potential and volumetric analysis
CO5: Ability to understand, explain predict various rules involve in chemical bonding
CO6: Understanding of anomalous behaviour of elements</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**ATOMIC STRUCTURE** Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.	15
II	**PERIODICITY OF ELEMENTS** *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.	15

	(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio	
III	**CHEMICAL BONDING-I** (i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. (iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.	15
IV	**CHEMICAL BONDING-II AND OXIDATION-REDUCTION** *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of *s-p* mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.	15

Suggested Readings:

1. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Edition, Oxford University Press, 2014.
2. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
3. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
4. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
5. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Inorganic Chemistry Practical-I</td><td colspan="5">Course Code:
SBS CH 020102 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Skill to handle preparation of various solutions, estimation of metal ions in the sample during performing experiments.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To acquire the skills to know about titrimetric analysis, acid-base titrations and oxidation-reduction titrimetry during the experiments. Also to carry out separation of mixtures of inorganic compounds by different methods.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic knowledge of inorganic preparation
CO2: Preparation of various solutions
CO3: Separation of ions from the mixtures
CO4: Estimation of ions from the mixtures
CO5: Knowledge about indicators
CO6: To work-up, isolate and purify, determine the purity of the prepared compound</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">TITRIMETRIC ANALYSIS
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants
ACID-BASE TITRATIONS
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents</td><td>35</td></tr>
<tr><td>III</td><td colspan="6">OXIDATION-REDUCTION TITRIMETRY
(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.</td><td>25</td></tr>
<tr><td colspan="8">Suggested Readings:
1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis 6th Edition, Pearson, 2009.</td></tr>
</table>

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Organic Chemistry-I</td><td colspan="3">Course Code:
SBS CH 020103 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. (Chemistry)</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic knowledge of chemical structures of the simple organic compounds.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide basic knowledge of organic chemistry, reactions such as addition reactions, elimination and substitution reactions, stereochemistry and basic chemistry of alkanes, alkenes, alkynes and aromatic hydrocarbons , cycloalkanes and conformational analysis.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Thorough knowledge of basics of organic chemistry
CO2: Basic understanding of stereochemistry
CO3: Basic chemistry of alkanes and alkenes
CO4: Ability to understand, explain and predict various aspects of cycloalkanes and conformational analysis.</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BASICS OF ORGANIC CHEMISTRY** Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Formulae representation: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions;	15
II	**STEREOCHEMISTRY** Isomerism: Types of isomerism, Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.	15

	Cycloalkanes and Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.	
III	**ALKANES AND ALKENES** Carbon-Carbon sigma bonds**:** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. Carbon-Carbon pi bonds**:** Formation of alkenes and alkynes by elimination reactions Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.	15
IV	**ALKYNES AND AROMATIC HYDROCARBONS** Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.	15

Suggested Readings:

1. J. Singh, L.D.S. Yadav, Organic Chemistry (Volume I), 14th Edition, Pragati Prakashan, 2019.
2. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
3. R. N. Boyd, R. T. Morrison and S. K. Bhattcharjee, Organic Chemistry, 7th Edition, Pearson, 2014.
4. S. M. Mukerji, S. P. Singh, K.P. Kapoor and R. Das, Organic Chemistry (Volume III), 2nd Edition, New Age International Publishers, 2014.
5. J. E. McMurry, Fundamentals of Organic Chemistry, 7th Edition, Cengage Learning India, 2013.
6. S. M. Mukerji, S. P. Singh, K.P. Kapoor and R. Das, Organic Chemistry (Volume II), 2nd Edition, New Age International Publishers, 2012.
7. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2nd Edition, New Age International Publishers, 2010.
8. P. S. Kalsi, Stereochemistry Conformation and Mechanism, New Age International, 2005.
9. I. L. Finar, Organic Chemistry (Volume 1), 6th Edition, Pearson, 2002.
10. I. L. Finar, Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), 5th Edition, Pearson, 2002.
11. E. L. Eliel & S. H. Wilen, Stereochemistry of Organic Compounds, Wiley: London, 1994.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Organic Chemistry Practical-I</td><td colspan="3">Course Code:
SBS CH 020104 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Common understanding of chemicals.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To inculcate the common skills required for performing organic chemistry practicals like m.p. and b.p. determination, crystallization and separation of compounds by thin layer chromatography.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: About the calibration of thermometer and its uses
CO2: Determination of b.p. and m.p. of the organic compounds purification of organic compounds
CO3: About the use of thin layer chromatography</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt both questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	1. Checking the calibration of the thermometer 2. Purification of organic compounds by crystallization using the following solvents: a) Water b) Alcohol c) Alcohol-Water 3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)	30
II	4.Effect of impurities on the melting point – mixed melting point of two unknown organic compounds 5.Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method) 6.Chromatography a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography b. Separation of a mixture of two sugars by ascending paper chromatography c. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC)	30

Suggested Readings:

1. B.S. Furniss ; A. J. Hannaford ; P.W.G. Smith ; A. R. Tatchell, Practical Organic Chemistry, 5th Edition., Pearson, 2012.
2. F.G. Mann & B.C. Saunders, Practical Organic Chemistry, Pearson, 2009.

Semester II

Course No:	Course Name: Physical Chemistry-I					Course Code: SBS CH 020201 C 3104		
Batch: 2022 onwards	Programme: Integrated B.Sc.-M.Sc.(Chemistry)	Semester:	L	T	P	Credit	Contact Hrs. per Week: 4
		II	3	1	0	4	Total Hrs.: 60
Total Evaluation Marks: 100 CIE: **30** Marks TEE: **70** Marks		**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry course up to Sen. Sec. level.					
Course Objectives	*To provide students with a basic understanding of physical chemistry, gaseous, liquid and solid state and ionic equilibria. This course will strengthen the fundamentals of physical chemistry, especially gaseous state, liquid state and solid state.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of physical chemistry. **CO2**: Use of gaseous, liquid and solid-state techniques in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate theoretical methods. **CO6**: Use of advanced and recent techniques in physical chemistry.						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students
need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**GASEOUS STATE** Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behavior, mention of other equations of state (Berthelot, dielectric or Dieterici); virial equation of state; van der Waals equation expressed in virial form and	15

	calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.	
II	**LIQUID STATE** Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water. Different bonding present in solid and liquid state of water. Difference in structure of liquid and solid state of water.	15
III	**SOLID STATE** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.	15
IV	**IONIC EQUILIBRIA** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.	15

Suggested Readings:

1. P. W. Atkins, and J. D. Paula, Atkin's Physical Chemistry, 10th Edition, *Oxford University Press* (2014).
2. T. Engel, and P. Reid, Physical Chemistry 3rd Edition, *Pearson* (2013).
3. R. G. Mortimer, Physical Chemistry 3rd Edition, *Elsevier,* NOIDA, UP (2009).
4. D. W. Ball, Physical Chemistry, *Thomson Press*, India (2007).
5. G. W. Castellan, Physical Chemistry 4th Edition, *Narosa Publication House* (2004).

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Physical Chemistry Practical-I</td><td colspan="4">Course Code:
SBS CH 020202 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc.(Chemistry</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week:</td></tr>
<tr><td>II</td><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with a basic understanding of laboratory techniques. This course will strengthen the fundamentals of analytical chemistry, and basics of physical chemistry practical techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of physical chemistry practical.
CO2: Use of surface tension, viscosity and indexing techniques in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate testing methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
</table>

COURSE SYLLABUS

NOTE: Depending on availability of time and equipment's, some experiments may be added/ deleted.

<table>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>Surface tension and Viscosity Measurements.
a. Determine the surface tension by (i) drop number (ii) drop weight method.
b. Study the variation of surface tension of detergent solutions with concentration.
c. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and(iii) sugar
at room temperature.
d. Study the variation of viscosity of sucrose solution with the concentration of solute.</td><td>30</td></tr>
<tr><td>II</td><td>Indexing by powder diffraction method of a cubic crystalline system.
a. Finding Miller indices of unknown XRD using JCPDS card file.
b. Determination of average particle size using Scherrer equation.
pH metry
a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH
i. Sodium acetate-acetic acid
ii. Ammonium chloride-ammonium hydroxide
c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d. Determination of dissociation constant of a weak acid.</td><td>30</td></tr>
</table>

Suggested Readings:

1. R. Gupta, Practical Physical Chemistry, *New Age International Pub. House*, New Delhi (2017).
2. B. D. Khosla, V. C. Garg, and A . Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi (2011).
3. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition; McGraw-Hill, New York (2003).
4. A. M. Halpern, and G. C. Mc. Bane, Experimental Physical Chemistry 3rd Edition, W.H. Freeman & Co., New York (2003).

Course No:	Course Name: Organic Chemistry-II	Course Code: SBS CH 020203 C 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 onwards	Integrated B.Sc.-M.Sc. Chemistry	II	3	1	0	4	Total Hrs.: 60

Total Evaluation Marks: 100	**Examination Duration:** 3 Hrs.
CIE: **30** Marks **TEE:** **70** Marks	**Pre-requisite of course:** Knowledge of chemistry of halogenated hydrocarbons, preparation and properties of alcohols, phenols, ethers and epoxides, addition reactions of carbonyl compounds, carboxylic acids and their derivatives.
Course Objectives	*To provide students with basic understanding of chemistry of halogenated hydrocarbons, preparation and properties of alcohols, phenols, ethers and epoxides, structure reactivity and preparation of carbonyl compounds, carboxylic acids and their derivatives.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of chemistry of halogenated hydrocarbons **CO2:** Understanding of preparation and properties of alcohols, phenols, ethers and epoxides **CO3:** Understanding of addition reactions of carbonyl compounds **CO4:** Understanding the preparation, physical properties and reactions of carboxylic acids **CO5:** Understanding the preparation and reactions of Sulphur containing compounds **CO6:** Scope of organic reactions

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CHEMISTRY OF HALOGENATED HYDROCARBONS** *Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and SN^i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. *Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.	15
II	**ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES** *Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. *Phenols:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism. *Ethers and Epoxides:* Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.	15

III	**CARBONYL COMPOUNDS** Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC). Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	15
IV	**CARBOXYLIC ACIDS AND THEIR DERIVATIVES** Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.	15

Suggested Readings:

1. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc (2009).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning (2013).
3. P. Sykes, *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman, New Delhi, 6th Edition (1997),
4. 4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India (2003).

<table>
<tr><td colspan="1">Course No:</td><td colspan="5">Course Name:
Organic Chemistry Practical-II</td><td colspan="3">Course Code:
SBS CH 020204 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: functional group tests, preparation of Organic compounds</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To provide students with basic understanding of functional group tests, preparation of Organic compounds</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding of Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
CO2: Understanding of preparation of inorganic compounds
CO3: Learn organic chemistry through experiments</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

<table>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>Identification of elements and FUNCTIONAL GROUP TESTS
Identification of elements (N, S, and halogen) and functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.</td><td>30</td></tr>
<tr><td>II</td><td>ORGANIC PREPARATIONS
i. Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
a. Using conventional method.
b. Using green approach
ii. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.
iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
iv. Bromination of any one of the following:
a. Acetanilide by conventional methods
b. Acetanilide using green approach (Bromate-bromide method)
v. Nitration of any one of the following:
a. Acetanilide/nitrobenzene by conventional method
b. Salicylic acid by green approach (using ceric ammonium nitrate).
vi. Selective reduction of meta dinitrobenzene to m-nitroaniline.
vii. Reduction of p-nitrobenzaldehyde by sodium borohydride.
viii. Hydrolysis of amides and esters.
ix. Semicarbazone of any one of the following compoundsacetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.</td><td>30</td></tr>
</table>

	x. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). xi. Aldol condensation using either conventional or green method. xii. Benzil-Benzilic acid rearrangement. The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.	

Suggested Readings:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

Semester III

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Physical Chemistry-II</td><td colspan="5">Course Code:
SBS CH 020301 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc.(Chemistry)</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of basic physical chemistry course up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with a basic understanding of chemical thermodynamics, and chemical equilibrium. This course will strengthen the fundamentals of thermodynamics, especially chemical thermodynamics, and chemical equilibrium.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of chemical thermodynamics.
CO2: Use of chemical thermodynamics in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important chemical methods.
CO5: Development of alternate physical chemistry methods.
CO6: Use of advanced and recent chemical thermodynamic chemistry.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHEMICAL THERMODYNAMICS-I** Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. *Second Law:* Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. *Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.	15
II	**SYSTEMS OF VARIABLE COMPOSITION and CHEMICAL THERMODYNAMICS-II**	15

	Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **CHEMICAL THERMODYNAMICS-II** *Thermochemistry:* Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature. *Free Energy Functions:* Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.	
III	**CHEMICAL EQUILIBRIUM** Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.	15
IV	**SOLUTIONS AND COLLIGATIVE PROPERTIES** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.	15

Suggested Readings:

1. A. Peter, and J. Paula, Physical Chemistry 10th Edition, *Oxford University Press* (2014).
2. T. Engel, and P. Reid, Physical Chemistry 3rd Edition, *Prentice-Hall* (2012).
3. M. J. Assael, A. R. H. Goodwin, M. Stamatoudis, W. A. Wakeham, and S. Will, Commonly asked questions in thermodynamics. *CRC Press*, New York (2011).
4. I. N. Levine, Physical Chemistry 6th Edition, *Tata Mc Graw Hill* (2010).
5. C. R. Metz, 2000 solved problems in chemistry, *Schaum Series* (2006).
6. G. W. Castellan, Physical Chemistry 4th Edition, *Narosa* (2004).
7. D. A. McQuarrie, and J.D. Simon, Molecular Thermodynamics, *Viva Books Pvt. Ltd*., New Delhi (2004).

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Physical Chemistry Practical-II</td><td colspan="5">Course Code:
SBS CH 020302 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to Sen. Sec. level.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To provide students with a basic understanding of laboratory techniques. This course will strengthen the fundamentals of analytical chemistry, and basics of physical chemistry practical techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic understanding of physical chemistry practical.
CO2: Use of surface tension, viscosity and indexing techniques in daily life.
CO3: Skills for analyzing and developing new sustainable methods.
CO4: Skills for developing industrially important practical methods.
CO5: Development of alternate testing methods.
CO6: Use of advanced and recent techniques in experimental chemistry.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE: Depending on availability of time and equipment's, some experiments may be added/ deleted.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**THERMOCHEMISTRY-I** (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization). (b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide. (c) Calculation of the enthalpy of ionization of ethanoic acid. (d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.	**30**
II	**THERMOCHEMISTRY-II** (a) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step. (b) Determination of enthalpy of hydration of copper sulphate. (c) Study of the solubility of benzoic acid in water and determination of ΔH.	**30**

Suggested Readings:

1. R. Gupta, Practical Physical Chemistry, *New Age International Pub. House*, New Delhi (2017).
2. J. B. Yadav, Advanced Practical Physical Chemistry, *Krishana Prakashan Media, Pvt. Ltd*. (2015).
3. B.D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi (2011).
4. V. D. Athawale, and P. Mathur, Experimental Physical Chemistry, *New Age International*, New Delhi (2001).
5. A. M. Halpern, and G. C. Mc. Bane, Experimental Physical Chemistry 3rd Edition, W.H. Freeman & Co., New York (2003).

Course No:	Course Name: Organic Chemistry-III					Course Code: SBS CH 020303 C 3104		
Batch: 2022 onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** III	**L** 3	**T** 1	**P** 0	**Credits** 4	**Contact Hrs. per Week: 04**	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of nitrogen containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, alkaloids, terpenes
Course Objectives	*To provide students with basic understanding of nitrogen containing functional groups, preparation of polynuclear hydrocarbons, introduction of heterocyclic compounds, general features of alkaloids, terpenes*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Nitrogen containing functional groups and their reactions. **CO2:** Familiarization with polynuclear hydrocarbons and their reactions. **CO3:** Heterocyclic compounds and their reactions. **CO4:** Alkaloids and Terpenes **CO5:** Understanding reactions and reaction mechanism of nitrogen containing functional groups. **CO6:** Understanding the reactions and mechanisms of diazonium compounds.

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**NITROGEN CONTAINING FUNCTIONAL GROUPS** Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications.	15
II	**POLYNUCLEAR HYDROCARBONS** Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.	15

III	**HETEROCYCLIC COMPOUNDS** Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.	15
IV	**ALKALOIDS AND TERPENES** Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.	15

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

Course No:	**Course Name:** Organic Chemistry Practical-III	**Course Code:** SBS CH 020304 C 0042

Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**
2022 onwards	Integrated B.Sc.-M.Sc. Chemistry	III	0	0	4	2	**Total Hrs.: 60**

Total Evaluation Marks: 100	**Examination Duration:** 6 Hrs.
CIE: **15** Marks **TEE:** **35** Marks	**Pre-requisite of course:** functional group tests, preparation of Organic compounds

Course Objectives	*To provide students with basic understanding of* functional group tests, preparation of Organic compounds
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group. **CO2:** Understanding of preparation of organic compounds **CO3**: Learn organic chemistry through experiments **CO4:** Preparation of methyl orange **CO5:** Extraction of caffeine from tea leaves **CO6:** Analysis of Carbohydrate

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	**Contents**	**Contact Hrs.**
I	1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc. 2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill). 3. Preparation of methyl orange. 4. Extraction of caffeine from tea leaves. 5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures.	60

Suggested Readings:

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

<table>
<tr><td colspan="2">Course No:</td><td colspan="5">Course Name:
Molecular Spectroscopy & Photochemistry</td><td colspan="3">Course Code:
SBS CH 020305 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2" colspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of radiation and its interaction with matter. Knowledge of rotation, vibration in molecules.</td></tr>
<tr><td colspan="2">Course Objectives</td><td colspan="8">To provide students with basic understanding of various spectroscopic techniques such as rotational spectroscopy, FTIR spectroscopy, Raman spectroscopy and electronic spectroscopy. The students will be also equipped with understanding of photophysical and photochemical processes.</td></tr>
<tr><td colspan="2">Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding of basic principles of spectroscopy
CO2: Understanding of concept of rotational spectroscopy
CO3: Knowledge of vibrational spectroscopy, both FTIR and Raman
CO4: Understanding principles of electronic spectroscopy
CO5: Understanding the concept of photophysical phenomena
CO5: Understanding of photochemistry</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
<tr><td>Unit No.</td><td colspan="8">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="8">GENERAL PRINCIPLES AND ROTATIONAL SPECTROSCOPY
Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.</td><td>15</td></tr>
<tr><td>II</td><td colspan="8">VIBRATIONAL SPECTROSCOPY
Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.</td><td>15</td></tr>
<tr><td>III</td><td colspan="8">RAMAN AND ELECTRONIC SPECTROSCOPY
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.
Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.</td><td>15</td></tr>
</table>

IV	**PHOTOPHYSICAL AND PHOTOCHEMICAL PROCESSES** Laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. Kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and its applications).	15

Suggested Readings:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition, International (1999).
2. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill, International (1995).
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, University Science Books (1998).
4. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age, revised second edition (2017).
5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi, (2006).

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Spectroscopy Practical</td><td colspan="4">Course Code:
SBS CH 020306 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of indicators, colorimetry, Lambert-Beers law</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To skill students about determination of indicator constant of various indicators by colorimetry and verify Beer's law for determining concentration of a given solution by colorimetry.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Practical understanding of Colorimetry
CO2: Knowledge of indicator constant
CO3: Practical understanding of Beer's law
CO4: Understanding of the determination of concentration of solutions
CO5: Develop skill of using a Colorimeter
CO6: Understanding of adsorption</td></tr>
</table>

<table>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td colspan="3">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>COLORIMETRY

Determination of indicator constant - colorimetry.</td><td>30</td></tr>
<tr><td>II</td><td>VERIFICATION OF BEER'S LAW
Verification of Beer's Law - Determination of concentration of solution by colorimetry.
(Instructor may explain the principle of using colorimeter, its handling drawing standard calibration curve, and its application in finding unknown concentration of dyes, concentration of metal solutions (e.g.Ni, Cu using appropriate reagent) from standard calibration curve.</td><td>30</td></tr>
</table>

Suggested Readings:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu, Macmillan (2009).

2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier (1968).

Semester IV

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Physical Chemistry-III</td><td colspan="4">Course Code:
SBS CH 020401 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Concept of phases, components and degrees of freedom, Order and molecularity of a reaction, Types of catalyst, specificity and selectivity, Physical adsorption, chemisorption.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Concept of phases, components and degrees of freedom, Order and molecularity of a reaction, Types of catalyst, specificity and selectivity, Physical adsorption, chemisorption.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Phases, components, Gibbs phase rule, Phase diagrams and applications.
CO2: Chemical kinetics: type of reactions, determination of rate, theories of reaction rate, steady state approximation.
CO3: Catalyst – mechanism, acid base catalysis, enzyme catalysis.
CO4: Adsorption isotherms.
CO5: Understanding phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phase diagram.
CO6: Understanding the basics of chemical kinetics.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**PHASE EQUILIBRIA** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.	15

II	**CHEMICAL KINETICS** Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.	15
III	**CATALYSIS** Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.	15
IV	**SURFACE CHEMISTRY** Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.	15

Suggested Readings:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa , 2004.
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.
4. Engel, T. & Reid, P. *Physical Chemistry* Third Edition*,* Prentice-Hall,2012.
5. Zundhal, S.S. Chemistry concepts and applications Cengage India, 2011
6. Ball, D. W. Physical Chemistry Cengage India, 2012.
7. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP, 2009.
8. Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill, 2011.
9. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill, 2009.

Course No:	Course Name: Physical Chemistry-III Practical						Course Code: SBS CH 020402 C 0042
Batch: 2022 onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**
			0	0	4	2	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Determination of cell constant, Potentiometric titrations Determination of cell constant, Potentiometric titrations
Course Objectives	*Determination of cell constant, Potentiometric titrations*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Determination of cell constant **CO2:** Equivalent conductance, degree of dissociation and dissociation constant of a weak acid. **CO3:** Potentiometric titrations **CO4**: Conductometric titrations of Strong acid Vs. strong base **CO5:** Conductometric titrations of Strong acid vs. weak base. **CO6:** Potassium dichromate vs. Mohr's salt

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**Conductometry** 1 Determination of cell constant 2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid. 3.Conductometric titrations of: Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and (iv)weak acid vs. strong base, Strong acid vs. weak base.	30
II	**Potentiometry** Potentiometric titrations of: (i) Strong acid vs. strong base (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt.	30

Suggested Readings: 1 Khosla, B. D.; Garg, V. C. and Gulati, A. Senior Practical Physical Chemistry, R. Chand New Delhi, 2011. 2 Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry Eighth Edition; McGraw-Hill: New York, 2003. 3 Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York, 2003. (List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

Course No:	**Course Name:** Inorganic Chemistry-II				**Course Code:** SBS CH 020403 C 3104		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:** **04**
			3	1	0	4	**Total Hrs.:** **60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Idea of metallurgy, HSAB principle, chemistry of s and p Block Elements, inorganic polymers, occurrence and uses of noble gases.					
Course Objectives	*To provide students with basic understanding of* Principles of metallurgy, concept of acid-base reactions, Chemistry of s and p Block Elements, occurrence and nature of bonding in noble gas compounds.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of principles of metallurgy **CO2:** Understanding the concept of acid-base reactions **CO3:** Understanding the basic properties of elements of s and p Block **CO4:** Understanding of occurrence and nature of bonding in noble gas compounds **CO5:** Understanding the Types of inorganic polymers **CO6:** Scope of inorganic compounds/polymers						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**GENERAL PRINCIPLES of METALLURGY** Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.	15
II	**CHEMISTRY OF *s* AND *p* BLOCK ELEMENTS** Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.	15

	Hydrides and their classification. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. Synthesis, structural aspects and applications of silicones and siloxanes, borazines, silicates and phosphazenes, and polysulphates.	
III	**NOBLE GASES** Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).	15
IV	**INORGANIC POLYMERS** Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.	15

Suggested Readings:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS (1991).
2. Douglas, B.E; McDaniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. (1994).
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann (1997).
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH (1999).
5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition (2002).
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson (2010).
7. Atkins, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Course No:	Course Name: Inorganic Chemistry Practical-II					Course Code: SBS CH 020404 C 0042		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** IV	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:**	**04**
			0	0	4	2	**Total Hrs.:**	**60**

Total Evaluation Marks: 100 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Iodo / iodimetric titrations, inorganic preparations
Course Objectives	*To provide students with basic understanding of* Iodo / iodimetric titrations, preparation of inorganic compounds
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of Estimation of ions by Iodimetrically / iodometrically **CO2:** Understanding of Preparation of inorganic compounds **CO3:** Learn Inorganic chemistry through experiments

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**IODO / IODIMETRIC TITRATIONS** (i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically (iii) Estimation of available chlorine in bleaching powder iodometrically.	30
II	**INORGANIC PREPARATIONS** (i) Cuprous Chloride, Cu_2Cl_2 (ii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.	30

Suggested Readings:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson (2009).

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Introduction to Quantum Chemistry</td><td colspan="3">Course Code:
SBS CH 020405 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Introduction to black-body radiation and distribution of energy, Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, discussion of solution of wave functions, Average and most probable distances of electron from nucleus.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Introduction to black-body radiation and distribution of energy, Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, discussion of solution of wave functions, Average and most probable distances of electron from nucleus.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Introduction to black-body radiation and distribution of energy
CO2: Quantitative treatment of simple harmonic osciallator model
CO3: Qualitative treatment of hydrogen atom and hydrogen-like ions
CO4: Scope of Physical Chemistry
CO5: Representations of hydrogenic orbitals
CO6: Valence bond and molecular orbital approaches</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**UNIT-I** Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals.	20
II	**UNIT-II** Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions. Rigid rotator model and discussion of application of	20

	Schrodinger equation. idea about transformation to spherical polar coordinate, discussion on solution,	
III	**UNIT-III** Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H2, H2+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H2 (only wavefunctions, detailed solution not required) and their limitations.	20

Suggested Readings:

1. Laideler K. J. and Meiser J. M. Physical Chemistry Third Edition (International)1999
2. Levine I. N., Physical Chemistry, Fourth Edition), McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. Physical Chemistry- A Molecular Approach, University Science Books, 1998.
4. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
5. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).

<table>
<tr><td>Course No:</td><td colspan="6">Course Name:
Quantum Chemistry Practical</td><td colspan="3">Course Code:
SBS CH 020406 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="3">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: calculate the energy of various conformations of molecules, students gain hand-on experience in using open-source softwares, academic visit to computational labs to gain knowledge.</td></tr>
<tr><td>Course Objectives</td><td colspan="9">Calculate the energy of various conformations of molecules, students gain hand-on experience in using open-source softwares, academic visit to computational labs to gain knowledge.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: Building a molecular model
CO2: Instructor can demonstrate the students use of hyperchem software, Gaussian software – geometry optimization).
CO3: Basic idea is to encourage the students to get knowledge without keeping any rigid practical syllabus framework).</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
<tr><td>Unit No.</td><td colspan="8">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="8">UNIT-I
(i) The students may be demonstrated hyperchem lab activities – building a molecular model (leveling of atoms, editing individual atoms, changing bond order, centrering, rotation of atoms), Selection of calculation method (e.g.force field calculation, ab-initio set up), displaying calculated properties, (instructor may demonstrate Computer programs that calculate the energy of various conformations of molecules and predict the lowest energy, to learn how to construct or draw representations of molecules using a molecular modeling program called HyperChem (HyperCube, Inc.), to perform geometry optimizations (energy minimizations) to determine the lowest energy conformations of molecules).
(Depending upon the availability of infrastructure facilities, instructor can demonstrate the students use of hyperchem software, Gaussian software – geometry optimization). They can be allowed for academic visit to computational labs to gain knowledge and a report may be considered for viva voce/examination). Open source softwares may be used for lab demonstration and students may prepare a report along with viva-voce shall constitute practical examination. Instructor may encourage the students to gain hand-on experience in using open-source softwares</td><td>30</td></tr>
</table>

	(for perfoming various calculation as mentioned) in lab computers, periodic evaluation of which can also be accepted as conducting lab practical examination. Basic idea is to encourage the students to get knowledge without keeping any rigid practical syllabus framework). (Examples of the computational work that can be done: Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.	
II	**UNIT-II** ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene. iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules. (Software: ChemSketch, ArgusLab (www.planaria-software.com), TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.	30

Suggested Readings:

1.Essentials of computational chemistry – Theories and models, C. J. Crammer, Wiley, 2nd Edn.,
2.Principle and applications of quantum chemistry, V.K.Gupta, Elsevier, 2016.
3. Practicals in physical chemistry – a modern approach, P.S.Sindhu, Macmillan,
4. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.
5. A.R. Leach, *Molecular Modelling Principles and Application*, Longman, 2001.
6. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons, 1997.
7. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers, 2008.

Semester V

Course No:	Course Name:	Course Code:
	Inorganic Chemistry-III	SBS CH 020501 C 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 onwards	Integrated B.Sc.-M.Sc.(Chemistry)	V	3	1	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of coordination chemistry, transition elements, lanthanoids and actinoids, bioinorganic chemistry

Course Objectives	*To provide students with basic understanding of coordination chemistry, general properties of transition elements transition elements, lanthanoids and actinoids, bioinorganic chemistry*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes, chelate. **CO2:** Transition metals, its stability, color, oxidation states and complexes. **CO3:** Lanthanides, Actinides – separation, color, spectra and magnetic behavior **CO4:** Bioinorganic chemistry – metal ions in biological system, its toxicity; hemoglobin. **CO5:** Understanding the nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects. **CO6:** Understanding the transition metals stability in reactions, origin of colour and magnetic properties.

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**COORDINATION CHEMISTRY** Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination	15

	number 4 and 6, Chelate effect.	
II	**TRANSITION ELEMENTS** General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)	15
III	**LANTHANOIDS AND ACTINOIDS** Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).	15
IV	**BIOINORGANIC CHEMISTRY** Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.	15

Suggested Readings:

1. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth- Heinemann, 1997.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Inorganic Chemistry Practical-III</td><td colspan="3">Course Code:
SBS CH 020502 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc.(Chemistry)</td><td rowspan="2">Semester:
V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Qualitative semimicro analysis of mixtures, Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Qualitative semimicro analysis of mixtures, Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations.
CO2: Controlled synthesis of two copper oxalate hydrate complexes
CO3: Preparation of acetylacetanato complexes
CO4: Synthesis of ammine complexes
CO5: Analysis of copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc radicals
CO6: Exchange reactions</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	**Contents**	**Contact Hrs.**
I	1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed: Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible. 2. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors. 3. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λmax of the prepared complex using instrument). 4. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands	15

	like acetylacetone, DMG, glycine) by substitution method.	

Suggested Readings:

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education, 2002.
2. Marr & Rockett *Practical Inorganic Chemistry.* John Wiley & Sons 1972.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Analytical Chemistry</td><td colspan="3">Course Code:
SBS CH 020503 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:
V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Fundamentals of analytical chemistry, Basics of spectroscopic, basics of separation techniques and its applications.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Fundamentals of analytical chemistry, Basics of spectroscopic, basics of separation techniques and its applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Familiarization with fundamentals of analytical chemistry.
CO2: Basics of spectroscopic, thermal, electrochemical techniques
CO3: Learning basics of separation techniques and its applications.
CO4: Understanding analytical tools, statistical methods applied to analytical chemistry.
CO5: Understanding principle of UV-Vis spectroscopy and its applications.
CO6: Understanding principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS** Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.	15
II	**SPECTROSCOPY** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. **Vibration spectroscopy**: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra **UV-Visible Spectrometry:** Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.	15

III	**THERMAL ANALYSIS and SEPARATION TECHNIQUES** Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture. Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media. Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.	15
IV	**ELECTROANALYTICAL METHODS** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values.	15

Suggested Readings:

1 Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2 Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing California, USA, 1988.
3.Christian, G.D, Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4 Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5 Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Saunder College Publications, (1998).
6 Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood
John Wiley 1979.
7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.
8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998
9.Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5th Edn., Brooks & Cole (1997).

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Analytical Chemistry Practical</td><td colspan="3">Course Code:
SBS CH 020504 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc.(Chemistry)</td><td rowspan="2">Semester:

V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Paper chromatographic separation, Determine the pH of the given aerated drinks fruit juices, shampoos and soaps, Estimation of calcium, magnesium, phosphate, nitrate, Determination of Biological oxygen demand (BOD) and chemical oxygen demand (COD).</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Paper chromatographic separation, Determine the pH of the given aerated drinks fruit juices, shampoos and soaps, Estimation of calcium, magnesium, phosphate, nitrate, Determination of Biological oxygen demand (BOD) and chemical oxygen demand (COD).</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Chromatography
CO2: Solvent Extractions
CO3: Analysis of soil
CO4: Ion exchange
CO5: Spectrophotometry
CO6: Separation of amino acids from organic acids by ion exchange chromatography.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHROMATOGRAPHY** (i) Paper chromatographic separation of Fe^{3+}, Al^{3+} and Cr^{3+} (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values. (iii.) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values. (iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC	15
II	**SOLVENT EXTRACTIONS** (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.	15

	ii. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps. iii. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.	
III	**ANALYSIS OF SOIL** (i) Determination of pH of soil. (ii) Total soluble salt (iii) Estimation of calcium, magnesium, phosphate, nitrate	15
IV	**ION EXCHANGE and SPECTROPHOTOMETRY** (i) Determination of exchange capacity of cation exchange resins and anion exchange resins. (ii) Separation of metal ions from their binary mixture. (iii) Separation of amino acids from organic acids by ion exchange chromatography. (i). Determination of pKa values of indicator using spectrophotometry. (ii) Structural characterization of compounds by infrared spectroscopy. (iii) Determination of dissolved oxygen in water. (iv) Determination of chemical oxygen demand (COD). (v) Determination of Biological oxygen demand (BOD). (vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.	15

Suggested Readings:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.

Semester VI

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Green Chemistry</td><td colspan="3">Course Code:
SBS CH 020601 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc.(Chemistry)</td><td rowspan="2">Semester:

VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic introduction and explaining goals of Green Chemistry, twelve principles of Green Chemistry, Designing of Environmentally safe marine antifoulant, Combinatorial green.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Basic introduction and explaining goals of Green Chemistry, twelve principles of Green Chemistry, Designing of Environmentally safe marine antifoulant, Combinatorial green.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Green chemistry and its principles.
CO2: Green synthesis and reactions.
CO3: Green chemistry for sustainable solutions.
CO4: Understanding principles of green chemistry.
CO5: Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
CO6: Atom economy and design of chemical reactions using the principle.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO GREEN CHEMISTRY** Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry	15
II	**PRINCIPLES OF GREEN CHEMISTRY AND DESIGNING A CHEMICAL SYNTHESIS (12 CLASSES OF 60 MINUTES DURATION EACH)** Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts;	15

	maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).	
III	**GREEN SYNTHESIS / REACTIONS** 1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis). 2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction). 3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) 4 Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. 5 Designing of Environmentally safe marine antifoulant. 6 An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. 7 Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils	15
IV	**FUTURE TRENDS IN GREEN CHEMISTRY** Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.	15

Suggested Readings:

1.Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS (2000).
5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition, 2010.

<table>
<tr><td>Course No:</td><td colspan="6">Course Name:
Green Chemistry practical</td><td colspan="3">Course Code:
SBS CH 020602 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:
VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="3">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="8">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="8">Pre-requisite of course: Preparation and characterization of nanoparticles of gold using tea leaves, Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice, photoreduction of benzophenone to benzopinacol in presence of sunlight.</td></tr>
<tr><td>Course Objectives</td><td colspan="9">Preparation and characterization of nanoparticles of gold using tea leaves, Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice, photoreduction of benzophenone to benzopinacol in presence of sunlight.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: Preparation of biodiesel from vegetable/ waste cooking oil.
CO2: Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
CO3: Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex.
CO4: Use of molecular model kit to stimulate the reaction
CO5: Preparation and characterization of nanoparticles of gold using tea leaves
CO6: Mechanochemical solvent free synthesis of azomethines</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
<tr><td>Unit No.</td><td colspan="8">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="8">PREPARATIONS AND STUDY OF REACTIONS-I
1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. Preparation of biodiesel from vegetable/ waste cooking oil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates Green Chemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atom economy.</td><td>15</td></tr>
<tr><td>II</td><td colspan="8">PREPARATIONS AND STUDY OF REACTIONS-I
1. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
2. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
3. Mechanochemical solvent free synthesis of azomethines</td><td></td></tr>
</table>

	4. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex. 5. Photoreduction of benzophenone to benzopinacol in presence of sunlight.	

Suggested Readings:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).

2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).

3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).

4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7 (2013).

5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).

6. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).

7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition, 2010.

8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders, 1995.

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Materials Chemistry</td><td colspan="5">Course Code:
SBS CH 020603 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>VI</td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of materials synthesis and characterization, application of various materials such as zeolites.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Crystalline solids, crystal systems, Bravais lattices, coordination number, Introduction to Zeolites, Preparation of inorganic solids, Overview of nanostructures and nano-materials, Introduction, limitations of conventional engineering materials.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Crystalline solids – parameters, symmetry.
CO2: Silica based materials in applications.
CO3: Technological importance of ionic liquids, preparation of materials– using sol-gel technique.
CO4: Nano-structured materials, self-assembled structure.
CO5: Composites and its applications
CO6: Understanding basic parameters of crystalline solids, symmetry and crystal structures.</td></tr>
</table>

<table>
<tr><td colspan="3" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="3">NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.</td></tr>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>BASICS OF CRYSTALLINE SOLIDS
Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism, twinning.</td><td>15</td></tr>
<tr><td>II</td><td>SILICA BASED MATERIALS
Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications.</td><td>15</td></tr>
</table>

III	**INORGANIC SOLIDS/IONIC LIQUIDS OF TECHNOLOGICAL IMPORTANCE** Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementary ideas).	15
IV	**NANOMATERIALS and COMPOSITE MATERIALS** Overview of nanostructures and nano-materials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.	15

Suggested Readings:

1.Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition, 2012.

3. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.

4. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003.

5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning, 2002.

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Materials Chemistry Practical</td><td colspan="6">Course Code:
SBS CH 020604 C 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Preparations of novalac resin/resol resin, Synthesis of materials/porous materials, Analysis of XRD pattern of crystals, Preparation of silver nano material.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Preparations of novalac resin/resol resin, Synthesis of materials/porous materials, Analysis of XRD pattern of crystals, Preparation of silver nano material.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Preparation of urea-formaldehyde resin
CO2: Analysis of XRD pattern of crystals.
CO3: Interpretation of FTIR, NMR and UV-Vis data of given material.
CO4: Determination of hydration number IR spectra.
CO5: Preparations of novalac resin/resol resin.
CO6: Preparation of silver nano material.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**PREPARATIONS OF MATERIALS** 1. Preparation of urea-formaldehyde resin 2. Preparations of novalac resin/resol resin 3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly, other materials synthesis can be designed). 4. Preparation of silver nano material. (Similarly, other nano materials of other metals synthesis can be designed).	30
II	**CHARACTERIZATION OF MATERIALS** 1. Analysis of XRD pattern of crystals. 2. Interpretation of FTIR, NMR and UV-Vis data of given material. 3. Estimation of particle size from the BET, SEM techniques. 4. Density measurement of ionic liquids 5. Determining dynamic viscosities of given ionic liquids 6. Determination of hydration number IR spectra.	30

Suggested Readings:

1.Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition, 2012.

3. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.

4. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003.

5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning, 2002.

List of Ability Enhancement Courses

Sr. No.	Name of the course	Course Code	L	T/P	P	Credits
1	English for Communication	SBS CH 0201 AE 3104	3	1	0	4
2	History of Indian Science	SBS CH 0202 AE 3104	3	1	0	4
3	Good Laboratory Practices	SBS CH 0203 AE 3104	3	1	0	4
4	Cheminformatics	SBS CH 0204 AE 3104	3	1	0	4
5	Research methodology	SBS CH 0205 AE 3104	3	1	0	4
6	Chemistry in Everyday life	SBS CH 0206 AE 3104	3	1	0	4

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
English for Communication</td><td colspan="3">Course Code:
SBS CH 0201 AE 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I/II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Idea of general English, English grammar, English sentence framing.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To skill students in English communication, in English writing, technical writing in English and scientific or general science presentation in English.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding of language and differentiate between writing and speech
CO2: Understanding of way of writing thesis and argumentative writing
CO3: Understanding the difference between formal and informal writing
CO4: Understanding the different forms of technical writing
CO5: Understanding of avoiding the common errors
CO6: Understanding of making a scientific presentation</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	**Contents**	**Contact Hrs.**
I	**COMMUNICATION** Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.	15
II	**WRITING SKILLS** Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.	15
III	**TECHNICAL WRITING** Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.	15
IV	**PRESENTATION SKILL** Scientific presentation, presentations related to general topic of science, animation, editing.	15

Suggested Readings:

5. O. Blackswan, Language, Literature and Creativity (2013).
6. Business English, Pearson (2008).
7. Fluency in English-Part II, Oxford University Press (2006).
8. Dr. G. Mishra, Dr. R. Kaul and Dr. B. Biswas, Language through Literature (forthcoming) Edition.

Course No:	Course Name: History of Indian Science	Course Code: SBS CH 0202 AE 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 Onwards	Integrated B.Sc.-M.Sc. Chemistry	I/II	3	1	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Knowledge of history of India, knowledge of important contributions from Indian scientist in various areas of science.
Course Objectives	*To provide students a knowledge of advancement in ancient science and the progress it made after independence and path breaking research by prominent scientists*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of innovations and development in science in ancient India **CO2:** Understanding of research organizations like CSIR, DRDO, ICAR and ICMR **CO3:** Understanding about the prominent scientists who have taken Indian science to international level **CO4:** Understanding of history of plant tissue culture in India **CO5:** Understanding of the green revolution in India, first gene cloning and first genome sequencing **CO6:** Understanding of allelopathy plant research in India

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**SCIENCE IN ANCIENT AND MEDIEVAL INDIA** History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques of irrigation.	15
II	**INDIAN SCIENCE IN BEFORE AND AFTER INDEPENDENCE** Introduction of different surveyors, botanists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, Establishment of Atomic Energy Commission, Launching of the space satellites, Botanical survey of India.	15
III	**PROMINENT INDIAN SCIENTISTS** Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Vikram Sarabhai.	15

IV	**PROMINENT RESEARCH IN PLANT SCIENCES IN REPUBLIC OF INDIA** History of plant tissue culture from India, Green revolution in India: causes, details, and outcomes. First gene cloning in plants, First genome sequencing from India. Premier Plant Research institutes and scientists in India, GM Mustard. Allelopathy Plant research in India.	15

Suggested Readings:

1. Kuppuram G (1990) History of Science and Technology in India, South Asia Books.
2. 2. Handa O. C. (2014) Reflections on the history of Indian Science and Technology, Pentagon Press.
3. 3. Basu A (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi & Co.
4. 4. Habib I, (2016.)A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. 5. A. Rahman et al (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. 6. B. V. Subbarayappa & K. V. Sarma (1985), Indian Astronomy -– A Source Book, Bombay.
7. 7. Srinivasan S, Ranganathan S (2013) Minerals and Metals heritage of India, National Institute of Advanced Studies.
8. 8. Srinivasiengar C N, (1967) The History of Ancient Indian Mathematics, World Press Private Ltd. Calcutta.
9. 9. Bhardwaj H C (2000) Metallurgy in Indian Archaeology. Tara Book Agency

Course No:	Course Name: Good Laboratory Practices					Course Code: SBS CH 0203 AE 3104		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** I/II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:** **04**	
			3	1	0	4	**Total Hrs.:** **60**	
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Experience of working in science laboratories and performing small experiments, knowledge of laboratory equipment and accessories.						
Course Objectives	*To skill students in laboratory practices, instrument usage, safety practice like handling acids with care*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of common calculations **CO2:** Understanding of preparation of solutions of different normality and molarity **CO3:** Understanding the use of different instruments **CO4:** Understanding of preparation of crystals, dyes **CO5:** Understanding of safety precautions while in laboratory **CO6:** Understanding of importance of cleanliness in laboratory							

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**GENERAL LABORATORY PRACTICES** Common calculations in chemistry laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.	15
II	**INSTRUMENT-TECHNIQUES AND LABORATORY PREPARATION PROCEDURE** Use of micropipette, analytical balances, pH meter, conductivity meter, rotary evaporator, potentiometer. Use of purified water in lab experiments, Cleaning and drying of glasswares, Perpartion of crystals from given salt. Preparation of Dyes, Demonstraton of preparation of material using Sol-gel procedure.	15
III	**GENERAL SAFETY PRACTICES** Precautious use of acids, wear safety googles and shoes in laboratory, use of extinguishable chemicals with much care, wear labcoat.	15
IV	**CLEANLINESS PRACTICE IN LABORATORY** Practice to keep the laboratory clean, proper storage of chemicals	15

Suggested Readings:

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 2nd ed.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.

Course No:	Course Name: Cheminformatics					Course Code: SBS CH 0204 AE 3104	
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** I/II	**L** 3	**T** 1	**P** 0	**Credits** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Knowledge of computer aided support in Chemistry, related softwares.					
Course Objectives	*To skill students about chemoinformatics, nomenclature, reaction classification, proper searching of chemical structures and its applications*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of prospects of chemoinformatics **CO2:** Understanding of nomenclature and reaction classification **CO3:** Understanding on how to search chemical structure **CO4:** Understanding the properties of compounds and structure and property relations **CO5:** Understanding the computational chemistry in elucidation of structure and design of synthesis **CO6:** Understanding of drug design, target identification and optimization						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO CHEMOINFORMATICS** History, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.	15
II	**REPRESENTATION OF MOLECULES AND CHEMICAL REACTIONS** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.	15
III	**SEARCHING CHEMICAL STRUCTURES** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	15
IV	**APPLICATIONS** Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling. Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand and structure based drug design; Applications in Drug Design.	15

Suggested Readings:

1. Andrew R. Leach and Valerie, J. Gillet (2007) An introduction to Chemoinformatics. Springer: The Netherlands.
2. Gasteiger, J. and Engel, T. (2003) Chemoinformatics: A text-book. Wiley-VCH.
3. Gupta, S. P. (2011) QSAR & Molecular Modeling. Anamaya Pub.: New Delhi.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Research methodology</td><td colspan="3">Course Code:
SBS CH 0205 AE 3104</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

I/II</td><td>L

3</td><td>T

1</td><td>P

0</td><td>Credits

4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.

Pre-requisite of course: Knowledge of research, good practices in research, idea of journals and publications.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">To skill students about research, different types of research, data collection and publishing of research work</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understanding of different types of research
CO2: Understanding of research methods and methodology
CO3: Understanding the data collection and maintaining laboratory record
CO4: Understanding the different research areas of chemistry
CO5: Understanding of various instruments to characterize the research
CO6: Understanding of publication of research</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC CONCEPTS OF RESEARCH** Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs. qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.	15
II	**DATA COLLECTION AND DOCUMENTATION OF OBSERVATIONS** Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.	15
III	**OVERVIEW OF APPLICATION TO CHEMISTRY RELATED PROBLEMS** Key chemistry research areas, chemoinfomatics.	15
IV	**BASIC KNOWLEDGE OF PUBLICATION HOUSE, JOURNALS AND INSTRUMENTATION** Characterization of samples, Instruments used for characterization, Publish the research, Access different publication house and journals associated with it, Research articles.	15

Suggested Readings:

1. A. Fink, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
2. M. Graziano, A.M. Anthony and M. L. Raulin, Research Methods: A Process of Inquiry, Allyn and Bacon., 2009.
3. W. M. K. Trochim, Research Methods: the concise knowledge base, Atomic Dog Publishing, 2005.
4. P. D. Leedy and J. E. Ormrod, Practical Research: Planning and Design, Prentice Hall, 2004.
5. B. L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal, An introduction to Research Methodology, RBSA Publishers, 2002.
6. R. A. Day, How to Write and Publish a Scientific Paper, Cambridge University Press, 1992.
7. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 1990.

Course No:	Course Name: Chemistry in Everyday life						Course Code: SBS CH 0206 AE 3104
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** I/II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**
			2	0	2	4	**Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Knowledge of different chemical processes people use in their everyday life in terms food habits, physical activities etc.						
Course Objectives	*To teach students how much chemistry is an integral part of our everyday life, impact of radicals on human health, vitamin and mineral chemistry,*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of mechanism of energy production via respiratory system **CO2:** Understanding of chemistry behind hazardous diseases **CO3:** Understanding the mechanism behind the formation and working of everyday life polymeric materials **CO4:** Understanding role of vitamins and minerals in body and their working mechanism **CO5:** Understanding of radical production and their impact on health **CO6:** Understanding of superoxide, peroxide and anti-oxidants						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**RESPIRATION AND ENERGY PRODUCTION IN HUMAN BODY** Respiration, Respiratory enzymes, brief outline of hemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanine, hemerythrine. Energy production in body, ATP; enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.	15
II	**CHEMICAL ASPECTS OF SOME COMMON HEALTH HAZARDS AND CHEMISTRY OF MATERIALS** Anemia, sickle cell anemia, leukemia, blood pressure irregulation, blood sugar, arthritis, carbon monoxide poisoning in mines, cyanide poisoning, fluorosis etc. Soaps and Detergents – their action, Biofuels – production of biofuels and its utility as alternative fuel source, Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA; Examples of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers. Use of polymeric materials in daily life.	15
III	**VITAMINS AND MINERALS** Need for vitamin in body, types of vitamins, water soluble and fat soluble vitamins, Vitamin B-12, vitamin C (Cyanocobalamine), D, Vitamin K. Role of minerals in body, iodine deficiency and remedy.	15

IV	**SIGNIFICANCE OF RADICAL CHEMISTRY IN LIVING SYSTEM** Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural anti-oxidants like vegetables, beverages like tea and coffee, fruits. Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.	15

Suggested Readings:

1. Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley, 1994.
2. 2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, Elsevier, 2008.
3. 3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman, 2008.
4. 4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) *Bioinorganic Chemistry.* University Science Books (1994)
5. 5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.
6. 6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International.

List of Skill Enhancement Courses

Sr. No.	Name of the course	Course Code	L/P	T	P	Credits
1	Personality Development	SBS CH 0201 SE 2002	2	0	0	**2**
2	Computer Applications in Chemistry	SBS CH 0202 SE 2002	2	0	0	**2**
3	Science Communication and Popularization	SBS CH 0203 SE 2002	2	0	0	**2**
4	Biofertilizer	SBS CH 0204 SE 2002	2	0	0	**2**
5	Herbal Science & Technology	SBS CH 0205 SE 2002	2	0	0	**2**
6	Fermentation Science & Technology	SBS CH 0206 SE 2002	2	0	0	**2**
7	Environment Impact Analysis	SBS CH 0207 SE 2002	2	0	0	**2**

<table>
<tr><td>Course No:</td><td colspan="6">Course Name:
Personality Development</td><td colspan="3">Course Code:
SBS CH 0208 SE 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I/II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="3">Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="8">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="8">Pre-requisite of course: Mental heuristics, Mental priming, Checklists, Stress management, Cognitive biases, Leadership qualities</td></tr>
<tr><td>Course Objectives</td><td colspan="9">Basic psychology skills, productivity and time management, dealing negativity, critical thinking and human resources</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: Develop understanding of the concepts and principles of basic psychological skills
CO2: Apply techniques and methods to enhance productivity and time management
CO3: Develop critical thinking skills
CO4: Organize human resources with improved leadership qualities
CO5: Improve logical fallacies
CO6: Overall personality development</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**BASIC PSYCHOLOGY SKILLS** Mental Heuristics and Priming, Cialdini's six psychological principles, Charisma and charisma enhancements, facing interviews	8
II	**PRODUCTIVITY AND TIME MANAGEMENT** Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling the events	8
III	**DEALING NEGATIVITY** Balance, stress management, coping with failures and depression	7
IV	**CRITICAL THINKING AND HUMAN RESOURCES** Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadership qualities.	7

Suggested Readings:

1. Bast, F., Crux of time management for students (2016). Available at: https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088
2. Cialdini, R.B., Influence: The Psychology of Persuasion, Revised Edition. Harper Collius (2001).
3. Green, C.J.,Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog Ear Publishing (2015).
4. Velayudhan, A. and Amudhadevi, N. V., Personality Development for College Students. LAP Lambert Academic Publishing (2012).

Course No:	Course Name: Computer Applications in Chemistry						Course Code: SBS CH 0209 SE 2002
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** I/II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 02**
			2	0	0	2	**Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Spreadsheet, Google search, Subscription, Bibliography, MS office, Image processing						
Course Objectives	*Spreadsheet Applications, Internet Resources, Bibliography management, Other software resources*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Apply the basic operations of spreadsheet applications **CO2:** Recognize advanced resources for accessing scholarly literature from internet **CO3:** Utilize bibliography management software while typing and downloading citations **CO4:** Operate various software resources with advanced functions and its open office substitutes						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**SPREADSHEET APPLICATIONS** Introduction of spreadsheet (MS Excel), application, formulas and functions, performing basic statistics using spreadsheet applications, creating basic graphs using spreadsheet applications, logical (Boolean) operators.	8
II	**INTERNET RESOURCES** Advanced Google search operators and Boolean functions, Introduction to Google Scholar and accessing scholarly literature from Internet, Fake News and spotting the fake news, multimedia resources and podcasts, RSS/XML Feeds and feed subscription using a feed reader.	8
III	**BIBLIOGRAPHY MANAGEMENT** Introducing a bibliography management software (for e.g. Endnote), Styles and Templates, Changing the bibliography style as per journal format, citing while typing in the office application, downloading citations from Google Scholar.	7
IV	**OTHER SOFTWARE RESOURCES** Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point, Microphotography and scale calibration with ImageJ, digital image processing (Paint.net or GIMP).	7

Suggested Readings:

1. User manual and online user manual of respective soft wares for the most updated content

2. Published books are not recommended as versions keep on updating very frequently; therefore, it is not easy to follow.

Course No:	Course Name: Science Communication and Popularization							Course Code: SBS CH 02010 SE 2002	
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** I/II	**L** 2	**T** 0	**P** 0	**Credits** 2	**Contact Hrs. per Week:**	**02**	
							Total Hrs.:	**30**	
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Print science, Visual media, Internet communication, Blogs, Outreach talks, Public sensitization								
Course Objectives	Print Science Communication, Visual Media Science Communication, Internet Science Communication, Science Outreach Talks and Public Sensitization								
Course Outcomes:	After completing this course, student is expected to learn the following: CO1: Identify the need and role of science communication in human development CO2: utilize visual media science communication for creating scripts and documentaries CO3: Contribute in science popularization through internet communication and public sensitization								

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**PRINT SCIENCE COMMUNICATION** Need for Science Journalism: Science has potential for breaking news, impact on Human life, impact on technology. Role of science and technology in human development. Framing policies at national and international levels. Writing and communicating popular articles effectively, case studies of celebrated works of science communicators including Cosmos by Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley, importance for communication through regional languages.	8
II	**VISUAL MEDIA SCIENCE COMMUNICATION** Advanced Google search operators and Boolean functions, Introduction to Google Scholar and accessing scholarly literature from Internet, Fake News and spotting the fake news, multimedia resources and podcasts, RSS/XML Feeds and feed subscription using a feed reader.	8
III	**INTERNET SCIENCE COMMUNICATION** Science outreach through internet: Social media, Websites, Blogs, Youtube, Podcast etc.	7
IV	**SCIENCE OUTREACH TALKS AND PUBLIC SENSITIZATION** Tactics for providing a charismatic and effective public talk, use of metaphors, speaking in context, Science outreach for biodiversity conservation sensitization of public	7

Suggested Readings:

1. Selected works of Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley.

2. Gigante, E. Marie (2018). Introducing Science Through Images: Cases of Visual Popularization (Studies in Rhetoric/Communication), University of South Carolina Press.

Course No:	Course Name: Biofertilizers						Course Code: SBS CH 02011 SE 2002	
Batch: 2022 Onwards	Programme: Integrated B.Sc.-M.Sc. Chemistry	Semester: I/II	L	T	P	Credits	Contact Hrs. per Week:	02
			2	0	0	2	Total Hrs.:	30

Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost
Course Objectives	Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost
Course Outcomes:	After completing this course, student is expected to learn the following: CO1: Develop their understanding on the concept of bio-fertilizer CO2: Identify the different forms of biofertilizers and their uses CO3: Compose the Green manuring and organic fertilizers CO4: Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**UNIT -1** General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis. Azospirillum: isolation and mass multiplication – carrier-based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	8
II	**UNIT -2** Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.	8
III	**UNIT -3** Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.	7
IV	**UNIT -4** Organic farming – Green manuring and organic fertilizers, Recycling of bio- degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	7

Suggested Readings:

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, New Delhi.

2. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.

3. Kumaresan, V.(2005). Biotechnology, Saras Publications, New Delhi.

4. NIIR Board. (2012). The complete Technology Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project Consultancy Services.

5. Sathe, T.V. (2004) Vermiculture and Organic Farming. Daya publishers.

6. Subba Rao N.S. (2017). Biofertilizers in Agriculture and Forestry. Fourth Edition. Medtech.

7. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad.

Course No:	Course Name: Herbal Science & Technology					Course Code: SBS CH 02012 SE 2002		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.- M.Sc. Chemistry	**Semester:** I/II	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week:**	**02**
			2	0	0	2	**Total Hrs.:**	**30**

Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites
Course Objectives	Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites
Course Outcomes:	After completing this course, student is expected to learn the following: CO1: Develop their understanding on Herbal Technology CO2: Define and describe the principle of cultivation of herbal products. CO3: List the major herbs, their botanical name and chemical constituents. CO4: Evaluate the drug adulteration through the biological testing CO5: Formulate the value-added processing / storage / quality control for the better use of herbal medicine CO6: Develop the skills for cultivation of plants and their value-added processing / storage / quality control

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**UNIT -1** Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products.	8
II	**UNIT -2** Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmeticals and biopesticides, their Botanical names, plant parts used, major chemical constituents.	8
III	**UNIT -3** Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, *Catharanthus roseus*, *Withania somnifera*, *Centella asiatica, Achyranthes aspera,* Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.	7

IV	**UNIT -4** Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value-added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation. of some medicinal plants (Withania somnifera, neem and tulsi),	

Suggested Readings:

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario of Herbal Technology worldwide: An overview. Int J Pharm Sci Res; 4(11): 4105-17.

2. Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications, Jaipur.

3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5: 88.

4. Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17 :987-1000.

5. Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp 218.

6. AYUSH (www.indianmedicine.nic.in). About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy. New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.

7. Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition, SAUNDERS / Elsevier.

8. Sivarajan, V.V. and India, B. (1994). Ayurvedic Drugs and Their Plant Sources. Oxford & IBH Publishing Company, 1994 - Herbs - 570 pages.

9. Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. Motilal Banarsidass,; Fourth edition .

10. Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan, Pune.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Fermentation Science & Technology</td><td colspan="3">Course Code:
SBS CH 02013 SE 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I/II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="2">Total Hrs.: 30</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Microbial culture, Fermentation, Metabolites, Fermented products, Enzyme production, Bioproduct recovery</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Microbial culture, Fermentation, Metabolites, Fermented products, Enzyme production, Bioproduct recovery</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Employ the process for maintenance and preservation of microorganisms
CO2: Analyze the various aspects of the fermentation technology and apply for Fermentative production
CO3: Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio product recover</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**UNIT -1** Preparation of microbial culture, Preparation and sterilization of fermentation media. Isolation and improvement of industrially important microorganisms.	8
II	**UNIT -2** Maintenance and preservation of microorganisms, Metabolic regulations and overproduction of metabolites. Kinetics of microbial growth and product formation.	8
III	**UNIT -3** Scope and opportunities of fermentation technology. Principles of fermentation: Submerged, solid state, batch, fed-batch and continuous culture. Fermentative production of vinegar, alcohol (ethanol, wine, beer), acids (citric acid and gluconic acid), amino acids (lysine and glutamic acid) and antibiotics (penicillin and streptomycin).	7
IV	**UNIT -4** Microbial production of enzymes: Amylase and Protease. Bioproduct recovery.	

Suggested Readings:

1. Waites M.J. (2008). Industrial Microbiology: An Introduction, 7th Edition, Blackwell Science, London, UK.

2. Prescott S.C., Dunn C.G., Reed G. (1982). Prescott & Dunn's Industrial Microbiology, 4th Edition, AVI Pub. Co., USA.

3. Reed G. (2004). Prescott & Dunn's industrial microbiology, 4th Edition, AVI Pub. Co., USA.

4. JR Casida L.E. (2015). Industrial Microbiology, 3rd Edition, New Age International (P) Limited Publishers, New Delhi, India.

5. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) Industrial Microbiology: An Introduction. 1st Edition, Blackwell Science, London, UK.

6. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
Environment Impact Analysis</td><td colspan="6">Course Code:
SBS CH 02014 SE 2002</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

I/II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="2">Total Hrs.: 30</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 2 Hrs.</td></tr>
<tr><td colspan="7">Environmental management, Environmental impact assessment, Project proponent, Consultant, Environmental audit, Risk assessment, Legislation</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Environmental management, Environmental impact assessment, Project proponent, Consultant, Environmental audit, Risk assessment, Legislation</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Have critical understanding of environmental impact
CO2: Learn important steps of EIA process
CO3: Interpret the environmental appraisal and procedures in India.</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ORIGIN AND DEVELOPMENT** Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.	8
II	**EIA PROCESS** Components of EIA, EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.	8
III	**MAIN PARTICIPANTS IN EIA PROCESS** Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA. Public participation.	7
IV	**ENVIRONMENTAL APPRAISAL AND PROCEDURES IN INDIA AND EIA** Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.	

	PRACTICAL 1. Prepare a Matrix of every environmental existing resource of your college or your hostel/mohalla or any defined area and evaluate each component using established methods and make audit analysis 2. Prepare a case report of Environmental impact of any area under development	

Suggested Readings:

1. Kulkarni V and Ramachandra TV, (2006). Environmental Management, Capital Pub. Co. New Delhi.
2. Petts, J. (2005) Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers, UK.
3. Glasson, J. Therivel, R. and Chadwick, (2006) A. Introduction to Environmental Impact Assessment. Routledge, London.
4. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, New York;
5. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL Press, London;
6. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science, Oxford;
7. Therivel, R. and Partidario, M. R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan, London;
8. Vanclay, F. and Bronstein, D. A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons, Chichester

List of Discipline Specific Elective Courses

Sr. No.	Name of the Course	Course Code	L	T	P	Credits
1	Medicinal Chemistry	SBS CH 0201 DSE 3104	3	1	0	**4**
2	Medicinal Chemistry Practical	SBS CH 0202 DSE 0042	0	0	4	**2**
3	Electrochemistry	SBS CH 0203 DSE 3104	3	1	0	**4**
4	Electrochemistry Practical	SBS CH 0204 DSE 0042	0	0	4	**2**
5	Advanced Material Chemistry	SBS CH 0205 DSE 3104	3	1	0	**4**
6	Material Chemistry Practical	SBS CH 0206 DSE 0042	0	0	4	**2**
7	Advanced Analytical Chemistry	SBS CH 0207 DSE 3104	3	1	0	**4**
8	Analytical Chemistry Practical	SBS CH 0208 DSE 0042	0	0	4	**2**
9	Organic Spectroscopy	SBS CH 0209 DSE 3104	3	1	0	**4**
10	Organic Spectroscopy Practical	SBS CH 0210 DSE 0042	0	0	4	**2**
11	Heterocyclic Chemistry	SBS CH 0211 DSE 3104	3	1	0	**4**
12	Heterocyclic Chemistry Practical	SBS CH 0212 DSE 0042	0	0	4	**2**
13	Organometallics and Bioinorganic Chemistry	SBS CH 0213 DSE 3104	3	1	0	**4**
14	Organometallics and Bioinorganic Chemistry Practical	SBS CH 0214 DSE 0042	0	0	4	**2**
15	Introduction to Nanochemistry & Applications	SBS CH 0215 DSE 3104	3	1	0	**4**
16	Nanochemistry Practical	SBS CH 0216 DSE 0042	0	0	4	**2**

Course No:	Course Name: Medicinal Chemistry	Course Code: SBS CH 0201 DSE 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 Onwards	Integrated B.Sc.-M.Sc. Chemistry	V/VI	3	1	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** The basics of medicinal chemistry, biophysical properties, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of stereochemistry in terms of biological response with examples
Course Objectives	The basics of medicinal chemistry, biophysical properties, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of stereochemistry in terms of biological response with examples
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** The basics of medicinal chemistry, biophysical properties **CO2:** Biological activity parameters **CO3:** Drug metabolism **CO4:** Biophysical and chemical properties of enzymes, hormones, vitamins **CO5:** Concept of rational drug design **CO6:** Synthesis, preparation and purification of medicinal compounds

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BIO-PHYSICOCHEMICAL PROPERTIES** Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i, K_d, LD_{50}, EC_{50}, IC_{50}, CC_{50}, ADMET properties	15
II	**STRUCTURAL PROPERTIES AND DRUG TARGET UNDERSTANDING** Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drug and recemates, Examples such as catecholamines, etc. Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.	15
III	**MEDICINAL CHEMISTRY OF THERAPEUTIC AGENT** Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardivascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents	15

IV	**STEROIDS, PROSTAGLANDINS, ENZYME, HORMONE AND VITAMINS, RATIONAL DRUG DESIGN** Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples. Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR.	15

Suggested Readings:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwer publication.
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACK Publishing.
4. Burgers Medicinal Chemistry by Manfred E. Wolff, Alfred Burger
5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, Hoboken N.J.Wiley,
6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press. 2012.
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society (1995)
8. Patrick, G. Medicinal Chemistry, Oxford.University Press (2000)

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Medicinal Chemistry Practical</td><td colspan="3">Course Code:
SBS CH 0202 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: The basics of medicinal chemistry, biophysical properties, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of stereochemistry in terms of biological response with examples.</td></tr>
<tr><td>Course Objective</td><td colspan="7">The basics of medicinal chemistry, biophysical properties, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of stereochemistry in terms of biological response with examples</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: The basics of medicinal chemistry, biophysical properties
CO2: Biological activity parameters
CO3: Drug metabolism
CO4: Biophysical and chemical properties of enzymes, hormones, vitamins
CO5: Concept of rational drug design
CO6: Synthesis, preparation and purification of medicinal compounds</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**PURIFICATION AND PREPARATION** 1.Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation 2.Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by Column Chromatography. 3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties. (Benzilic Acid & Sodium Benzoate)	30
II	**SYNTHESIS AND COMPUTATIONAL MODELING** Synthesis & Purification of following Compounds using: (i)Precipitation or Recrystallization. (ii)Synthesis of Benzimidazole. (iii)Synthesis of Anthranilic Acid. (iv)Synthesis of Sulphanilamide. (v)Synthesis of benzoic acid from benzyl alcohol. (vi)Synthesis of 1,4 – dihydropyridine. Computational modeling of drug design/use of softwares may be demonstrated to students.	30

Suggested Readings:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D. Barnes, M. J. K Thomas, 6th Edition, Pearson’s Education Ltd.
2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
3. Vogel‟s Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R Tatchell, 5th edition (2008), Pearson’s Education Ltd.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Electrochemistry</td><td colspan="3">Course Code:
SBS CH 0203 DSE 3104</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

V/VI</td><td>L
3</td><td>T
1</td><td>P
0</td><td>Credits
4</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.

Pre-requisite of course: Basic understanding electrochemistry, idea of electrochemical potential, knowledge of electrodes.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Basic principle of laws of electrochemistry, understanding about chemical cells and their function, understanding of potentiometric titrations and their applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basic principle of laws of electrochemistry.
CO2: Understanding about chemical cells and their function
CO3: Understanding about electrodes, EMF measurement.
CO4: Understanding about potentiometric titrations and their applications.
CO5: Designing electrochemical cell.
CO6: Use of electrochemical cell for various electrochemical reactions.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**Unit-I** Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.	15
II	**Unit-II** Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes. Concentration cells	15

	with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).	
III	**ELECTROANALYTICAL METHODS** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.	15
IV	**ELECTRICAL & MAGNETIC PROPERTIES OF ATOMS AND MOLECULES** Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardivascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents	15

Suggested Readings:

1.Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2.Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3.Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
4.Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5.Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6.Rogers, D. W. Concise Physical Chemistry Wiley (2010).
7.Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Electrochemistry Practical</td><td colspan="4">Course Code:
SBS CH 0204 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022 onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50
CIE: 15 Marks
TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding electrochemistry, idea of electrochemical potential, knowledge of electrodes.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Basic principle of laws of electrochemistry, understanding about chemical cells and their function, understanding of potentiometric titrations and their applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic principle of laws of electrochemistry.
CO2: Understanding about chemical cells and their function
CO3: Understanding about electrodes, EMF measurement.
CO4: Understanding about potentiometric titrations and their applications.
CO5: Designing electrochemical cell.
CO6: Use of electrochemical cell for various electrochemical reactions.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="6">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="6">DETERMINATION OF pH AND CELL CONSTANT
1.Determination of pH of a given solution using glass electrode.
2. Determination of cell constant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak acid.</td><td>30</td></tr>
<tr><td>II</td><td colspan="6">CONDUCTOMETRIC AND POTENTIOMETRIC TITRATION
1. Conductometric titration: strong acid vs. strong base, weak acid vs. strong base.
2. Potentiometric titration: strong acid vs. strong base, weak acid vs. strong base, potassium dichromate vs. mohr’s salt.</td><td>30</td></tr>
<tr><td colspan="8">Suggested Readings:
1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).</td></tr>
</table>

Course No:	Course Name: Advanced Materials Chemistry	Course Code: SBS CH 0205 DSE 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 Onwards	Integrated B.Sc.- M.Sc. Chemistry	V/VI	3	1	0	4	Total Hrs.: 60

Total Evaluation Marks: 100	**Examination Duration:** 3 Hrs.
CIE: **30** Marks **TEE:** **70** Marks	**Pre-requisite of course**: Idea of single crystals and X-ray diffraction, synthesis of nanomaterials and their characterization, knowledge of different microscopies.

Course Objectives	Introduction of Growth of single crystals, Crystal structure determination by X-ray diffraction, d-spacing formula, Synthesis of nanowires and nanotubes by CVD and MOCVD method, Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy, Biodegradable polymers.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Advanced idea of X-ray diffraction **CO2:** Structure solution by X-ray diffraction **CO3:** Synthesis and characterization of nanomaterials **CO4:** Use of nanomaterials in magnetism **CO5:** Knowledge of various types of polymers **CO6:** Idea of biodegradable polymers

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CRYSTAL STRUCTURE OF SOLIDS** Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant-based synthesis. Growth of single crystals. Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by an atom and a crystal. Single crystal and powder diffraction. Electron and neutron diffraction. Concept of reciprocal lattice. Electron microscopy techniques.	15
II	**NANOMATERIAL FUNDAMENTALS** Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials. Synthesis of nanowires and nanotubes by CVD and MOCVD method. Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy. Nanomaterial properties and applications: Magnetic properties of nanoparticles;	15

	superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. magnetic nanoparticles as MRI contrast agents.	
III	**POLYMER SCIENCE AND TECHNOLOGY** Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers. Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.	15
IV	**BIODEGRADABLE POLYMERS** Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells. Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.	15

Suggested Readings:

1. Zhen Guo and Li Tan, Fundamentals and Applications of Nanomaterials.2009, Artech House, London Publication.
2. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
3. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International (P) Ltd., 2015.
4. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Materials Chemistry Practical</td><td colspan="4">Course Code:
SBS CH 0206 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="5">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: Idea of single crystals and X-ray diffraction, synthesis of nanomaterials and their characterization, knowledge of different microscopies.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Introduction of Growth of single crystals, Crystal structure determination by X-ray diffraction, d-spacing formula, Synthesis of nanowires and nanotubes by CVD and MOCVD method, Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy, Biodegradable polymers.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Advanced idea of X-ray diffraction
CO2: Structure solution by X-ray diffraction
CO3: Synthesis and characterization of nanomaterials
CO4: Use of nanomaterials in magnetism
CO5: Knowledge of various types of polymers
CO6: Idea of biodegradable polymers</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**PREPARATION OF NANOMATERIALS AND POLYMERS** 1. Preparation of gold and silver nano-particles. 2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein	30
II	**X-RAY DIFFRACTION AND CHARACTERIZATION OF NANOMATERIALS** 1. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystalline system. 2. Interpretation of FTIR, NMR and UV-Vis data of given material. 3. Estimation of particle size from the BET, SEM techniques.	30

Suggested Readings:

1. Fahlman, B.D. Materials Chemistry, Springer, 2004.
2. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
3. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
4. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

Course No:	Course Name: Advanced Analytical Chemistry					Course Code: SBS CH 0207 DSE 3104		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.- M.Sc. Chemistry	**Semester:** V/VI	**L** 3	**T** 1	**P** 0	**Credits** 4	**Contact Hrs. per Week:** 04 **Total Hrs.:** 60	
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Knowledge of analytical chemistry, idea of errors and deviation, knowledge of characterization of materials.						
Course Objectives	Introduction of Theory of error and treatment of quantitative data, accuracy and precision, qualitative and quantitative applications, instruments and applications of theromogravimetric analysis, Principles of chromatography.							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Statistical methods in chemical analysis **CO2:** Polarography **CO3:** Atomic spectroscopy **CO4:** Thermal analysis **CO5:** Chromatography **CO6:** Analysis of fuel and drugs							

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**STATISTICAL METHODS IN CHEMICAL ANALYSIS** Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).	15
II	**POLAROGRAPHY AND ATOMIC SPECTROSCOPY** Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications. Atomic absorption spectroscopy, theory and application (with some examples).	15
III	**THERMAL ANALYSIS AND CHROMATOGRAPHY** Theory, methodology, instruments and applications of theromogravimetric analysis (TGA/DTA), and differential scanning calorimetry (DSC). Principles of chromatography, paper, column and thin layer chromatography, Gas-liquid chromatography, HPLC.	15

IV	**ANALYSIS OF FUEL AND DRUGS** **Fuel analysis:** Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel, Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point. **Drug analysis:** Classification of drugs, Analysis of some standard drug using various chromatographic techniques.	15

Suggested Readings:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA, 1988.
3. Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*
6. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood
7. John Wiley 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.
9. Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition) 1998

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Analytical Chemistry Practical</td><td colspan="4">Course Code:
SBS CH 0208 DSE 0042</td></tr>
<tr><td>Batch:
2022
onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

V/VI</td><td>L

0</td><td>T

0</td><td>P

4</td><td>Credit

2</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.

Pre-requisite of course: Knowledge of analytical chemistry, idea of errors and deviation, knowledge of characterization of materials.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Introduction of Theory of error and treatment of quantitative data, accuracy and precision, qualitative and quantitative applications, instruments and applications of theromogravimetric analysis, Principles of chromatography.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Statistical methods in chemical analysis
CO2: Polarography
CO3: Atomic spectroscopy
CO4: Thermal analysis
CO5: Chromatography
CO6: Analysis of fuel and drugs</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHROMATOGRAPHY** 1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. Preparation of buffer solutions of different pH (i. Sodium acetate-acetic acid, ii. Ammonium chloride-ammonium hydroxide 2. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Fe (III) and Al (III) 3.Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.	30
II	**CHARACTRIZATIONS** 1. IR/DSC analysis of known polymer sample (for students' demonstration only) 2. Determination of viscosity index, cloud point, pour point of given fuel sample. 3. Determination of calorific value of given fuel sample/coal sample using bomb calorimeter. 4. Determination of the iodine number of oil. 5. Determination of the saponification number of oil.	30

Suggested Readings:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009
4. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
Organic Spectroscopy</td><td colspan="4">Course Code:
SBS CH 0209 DSE 3104</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:

V/VI</td><td>L

3</td><td>T

1</td><td>P

0</td><td>Credits

4</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of radiation and its interaction with matter, idea of electronic levels in atoms and molecules, theory of molecular spectroscopy.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Application of visible, ultraviolet and infrared spectroscopy in organic molecules, Identification of Functional groups of various classes of organic compounds, Application of Chemical Shifts, Application of fragmentation rule in characterization of organic compounds.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Basic Principles of UV Spectroscopy
CO2: Basic principles of IR Spectroscopy
CO3: NMR (^{1}H and ^{13}C NMR)
CO4: Basic principles Mass Spectrometry
CO5: Use of spectroscopy in characterizing molecules
CO6: Study of unknown compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC PRINCIPLES OF UV SPECTROSCOPY** Application of Woodward-Fiser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.	15
II	**BASIC PRINCIPLES OF IR SPECTROSCOPY** Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).	15
III	**NMR (^{1}H AND ^{13}C NMR)** Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange	15

IV	**BASIC PRINCIPLES MASS SPECTROMETRY** Application of fragmentation rule in characterization of organic compounds. Problems on structure elucidation of organic compounds based on spectral data.	15

Suggested Readings:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India (2012).

Course No:	Course Name: Organic Spectroscopy Practical				Course Code: SBS CH 0210 DSE 0042		
Batch: 2022 onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** **V/VI**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			0	0	4	2	**Total Hrs.: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course**: Knowledge of radiation and its interaction with matter, idea of electronic levels in atoms and molecules, theory of molecular spectroscopy.						
Course Objectives	*Application of visible, ultraviolet and infrared spectroscopy in organic molecules, Identification of Functional groups of various classes of organic compounds, Application of Chemical Shifts, Application of fragmentation rule in characterization of organic compounds.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Basic Principles of UV Spectroscopy **CO2:** Basic principles of IR Spectroscopy **CO3:** NMR (^{1}H and ^{13}C NMR) **CO4:** Basic principles Mass Spectrometry **CO5:** Use of spectroscopy in characterizing molecules **CO6:** Study of unknown compounds						

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**PURIFICATION OF COMPOUNDS** Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy).	30
II	**CHARACTRIZATIONS** Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. Students need to identify/analyze important peaks/functionality, determine mass of the molecules (mass-spectra). They can submit a report regarding their analysis to course teacher.	30

Suggested Readings:

3. R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
4. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India (2012).

Course No:	Course Name: Heterocyclic chemistry				Course Code: SBS CH 0211 DSE 3104		
Batch: 2022 Onwards	Programme: Integrated B.Sc.- M.Sc. Chemistry	Semester: V/VI	L	T	P	Credits	Contact Hrs. per Week: 04
			3	1	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Knowledge of basic organic chemistry, synthesis and various reactions, knowledge of hetero atoms in compounds.
Course Objectives	*Synthetic approaches and reactivities, natural products: synthesis of Penicillin and cephalosporine, general synthetic approaches.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Three-membered rings **CO2:** Three-membered heterocycles with two heteroatoms **CO3:** Four-membered heterocycles **CO4:** Five-membered aromatic heterocycles **CO5:** Synthesis of heterocycles **CO6:** Knowledge of benzofurans and indoles

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**HETEROCYCLIC CHEMISTRY** Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches and reactivities. Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches and reactivities.	15
II	**FOUR-MEMBERED HETEROCYCLES** oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Peniciline and cephalosporine.	15
III	**FIVE-MEMBERED AROMATIC HETEROCYCLES** Application of fragmentation rule in characterization of organic compounds. Problems on structure elucidation of organic compounds based on spectral data.	15
IV	**CONDENSED FIVE-MEMBERED HETEROCYCLES** Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry of Indoles.	15

Suggested Readings:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley, 2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York, 1968.
4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London, 1978.
5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees), Vol 1-8, Pergamon Press, 1984.
6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press, 1985.
7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.

<table>
<tr><td colspan="1">Course No:</td><td colspan="5">Course Name:
Heterocyclic Chemistry Practical</td><td colspan="3">Course Code:
SBS CH 0212 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of basic organic chemistry, synthesis and various reactions, knowledge of hetero atoms in compounds.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Synthetic approaches and reactivities, natural products: synthesis of Penicillin and cephalosporine, general synthetic approaches.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Three-membered rings
CO2: Three-membered heterocycles with two heteroatoms
CO3: Four-membered heterocycles
CO4: Five-membered aromatic heterocycles
CO5: Synthesis of heterocycles
CO6: Knowledge of benzofurans and indoles</td></tr>
</table>

<table>
<tr><td colspan="3" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="3">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>IDENTIFICATION
1. Identification of hetero atoms (S, N, X) in given organic compounds in lab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) in lab.</td><td>30</td></tr>
<tr><td>II</td><td>SPECTROSCOPIC INDENTIFICATION AND PREPARATION
1. Spectroscopic identification of simple organic compounds (spectra may be provided to the students and teachers may help the students to identify the compounds using spectra). Melting point/boiling point of the compounds may be checked for its purity.
2. Preparation of Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basic condition).</td><td>30</td></tr>
</table>

Suggested Readings:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley, 2010.
2. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London, 1978.
3. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees), Vol 1-8, Pergamon Press, 1984.
4. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press, 1985.

Course No:	Course Name: Organometallics and Bioinorganic Chemistry	Course Code: SBS CH 0213 DSE 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs. per Week: 04
2022 Onwards	Integrated B.Sc.- M.Sc. Chemistry	V/VI	3	1	0	4	Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Knowledge of metal-carbon bonds and fundamentals of organometallic chemistry, idea of metals in biology, knowledge of proteins and enzymes.
Course Objectives	*Oxidation states displayed by Cr, Fe, Co, Ni and Co, General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series, stabilization of protein structures and structural role (bones).*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Chemistry of 3d metals **CO2:** Organometallic Compounds **CO3:** Bioinorganic chemistry **CO4:** Knowledge of various enzymes and proteins in biological systems **CO5:** Ion-transport **CO6:** Use of organometallic compounds in catalysis

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CHEMISTRY OF 3D METALS** Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.	15
II	**ORGANOMETALLIC COMPOUNDS-I** Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.	15
III	**ORGANOMETALLIC COMPOUNDS-II** Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.	15

	Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.	
IV	**BIOINORGANIC CHEMISTRY** A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^{+}, K^{+} and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).	15

Suggested Readings:

1.Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
4.Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
Organometallics and Bioinorganic chemistry Practical</td><td colspan="4">Course Code:
SBS CH 0214 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Knowledge of metal-carbon bonds and fundamentals of organometallic chemistry, idea of metals in biology, knowledge of proteins and enzymes.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Oxidation states displayed by Cr, Fe, Co, Ni and Co, General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series, stabilization of protein structures and structural role (bones).</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Chemistry of 3d metals
CO2: Organometallic Compounds
CO3: Bioinorganic chemistry
CO4: Knowledge of various enzymes and proteins in biological systems
CO5: Ion-transport
CO6: Use of organometallic compounds in catalysis</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">GRIGNARD REAGENT
1.Rection of metal with halide – preparation of Grignard reagent. (only demonstration purpose)
2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline) (only demonstration purpose)</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">PREPARATION OF COMPLEXES
1. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.
2. Preparation of any two of the following complexes and measurement of their conductivity measurement:
a. tetraamminecarbonatocobalt (III) nitrate
b. tetraamminecopper (II) sulphate
c. potassium trioxalatoferrate (III) trihydrate</td><td>30</td></tr>
<tr><td colspan="9">Suggested Readings:
1. Synthesis of organometallic compounds: A practical guide, S. Komiya, Wiley.
2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall.</td></tr>
</table>

<table>
<tr><td>Course No:</td><td colspan="6">Course Name:
Introduction to Nanochemistry & Applications</td><td colspan="3">Course Code:
SBS CH 0215 DSE 3104</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="3">Contact Hrs. per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="3">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="8">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="8">Pre-requisite of course: Knowledge of nanomaterials, its synthesis and characterizations, idea of carbon nanotubes, fullerene, graphene etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="9">Introduction to nanoscience, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties, Brief introduction about Top-down and Bottom-up approaches, Electron microscopic technique.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="9">After completing this course, student is expected to learn the following:
CO1: Introduction to nanoscience
CO2: Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.
CO3: Examples of preparation of gold and silver metallic nanoparticles,
CO4: Material characterization techniques
CO5: Advanced application of nanomaterials
CO6: Knowledge of quantum dots</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td colspan="10">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.	25
II	**PROPERTIES OF NANOMATERIALS** Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.	20
III	**SYNTHESIS OF NANOMATERIALS** Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.	

IV	**CHARACTERIZATION OF NANOMATERIALS** Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).	

Suggested Readings:

1.C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.

2.G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004

3.R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005

4.Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.

5. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
Nanochemistry Practical</td><td colspan="3">Course Code:
SBS CH 0216 DSE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td rowspan="2">Semester:

V/VI</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs.: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of nanomaterials, its synthesis and characterizations, idea of carbon nanotubes, fullerene, graphene etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">Introduction to nanoscience, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties, Brief introduction about Top-down and Bottom-up approaches, Electron microscopic technique.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Introduction to nanoscience
CO2: Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.
CO3: Examples of preparation of gold and silver metallic nanoparticles,
CO4: Material characterization techniques
CO5: Advanced application of nanomaterials
CO6: Knowledge of quantum dots</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">SYNTHESIS OF NANOPARTICLES
1.Synthesis of ZnO nanoparticles.
2. Preparation of Silver nanoparticles.
(diverse nanoparticles can be prepared by various routes)</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">BEER-LAMBERT LAW
Verfification of Beer-Lambert law using nano-particles (above prepared nano-particles may be used for the study).</td><td>30</td></tr>
<tr><td colspan="9">Suggested Readings:
1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.</td></tr>
</table>

List of GE Courses To Be Offered To The Other Departments

Sr. No.	Name of the course	Course Code	L	T	P	Credits
1	GE: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	SBS CH 020101 GE 4004	4	0	0	**4**
2	GE-Lab: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	SBS CH 020102 GE 0042	0	0	4	**2**
3	GE: Chemical Energetics, Equilibria & Functional Organic Chemistry-I	SBS CH 020103 GE 4004	4	0	0	**4**
4	GE Lab: Chemical Energetics, Equilibria & Functional Organic Chemistry-I	SBS CH 020104 GE 0042	0	0	4	**2**
5	Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry	SBS CH 020201 GE 4004	4	0	0	**4**
6	GE Lab: Solutions, Phase Equilibria, Conductance, Electrochemistry, & Functional Group Organic Chemistry	SBS CH 020202 GE 0042	0	0	4	**2**
7	GE: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics	SBS CH 020203 GE 4004	4	0	0	**4**
8	GE Lab: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics	SBS CH 020204 GE 0042	0	0	4	**2**
9	Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra	SBS CH 020301 GE 4004	4	0	0	**4**
10	GE Lab: Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons & UV, IR Spectra	SBS CH 020302 GE 0042	0	0	4	**2**
11	GE: Quantum Chemistry, Spectroscopy & Photochemistry	SBS CH 020303 GE 4004	4	0	0	**4**
12	GE Lab: Quantum Chemistry, Spectroscopy & Photochemistry	SBS CH 020304 GE 0042	0	0	4	**2**
13	Molecules of Life	SBS CH 020401 GE 4004	4	0	0	**4**

14	GE Lab: Molecules of Life	SBS CH 020402 GE 0042	0	0	4	**2**
15	Chemistry of Main Group Elements, Theories of Acids & Bases	SBS CH 020403 GE 4004	4	0	0	**4**
16	GE Lab: Chemistry of Main Group Elements, Theories of Acids & Bases	SBS CH 020404 GE 0042	0	0	4	**2**

Note:

1. University/Department may include more options or delete some from this list.
2. The courses will be offered according to faculty strength and as per availability of faculty members.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons</td><td colspan="5">Course Code:
SBS CH 020101 GE 4004</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc.</td><td>Semester:

I</td><td>L
4</td><td>T
0</td><td>P
0</td><td>Credits
4</td><td>Contact Hrs. per Week: 04
Total Hrs.: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 Hrs.

Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide basic knowledge of fundamentals of inorganic chemistry and organic chemistry to the students.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: The wave function
CO2: Structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams
CO3: Importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect
CO4: The nature and behavior of organic compounds
CO5:Mechanisms of several organic reactions including free radical/electrophilic substitution/addition
CO6: The fundamental concepts of stereochemistry</td></tr>
</table>

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

<table>
<tr><th>Unit No.</th><th>Contents</th><th>Contact Hrs.</th></tr>
<tr><td></td><td>INORGANIC CHEMISTRY-1</td><td></td></tr>
<tr><td>I</td><td>ATOMIC STRUCTURE

Review of Bohr’s theory and its limitations, dual behaviour of matter and radiation, de Broglie’s relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes</td><td>14</td></tr>
</table>

	of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number(*s*) and magnetic spin quantum number (*ms*). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.	
II	**CHEMICAL BONDING AND MOLECULAR STRUCTURE** **Ionic Bonding:** General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. **Covalent Bonding:** VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. **MO Approach:** Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.	16
	ORGANIC CHEMISTRY-1	
III	**FUNDAMENTALS OF ORGANIC CHEMISTRY** Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. **Stereochemistry**: Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis-trans* nomenclature; CIP Rules: R/S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).	16
IV	**ALIPHATIC HYDROCARBONS** Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. **Alkanes:** (Upto 5 Carbons) Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. **Alkenes:** (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic	14

	hydrogenation) and trans alkenes (Birch reduction). Reactions: cis addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. **Alkynes**: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$	

Suggested Readings:

1. J. Singh, L.D.S. Yadav, Organic Chemistry (Volume I), 14th Edition, Pragati Prakashan, 2019.
2. T.W. Graham Solomon, C.B. Fryhle, & S.A. Dnyder, Organic Chemistry, John Wiley & Sons, 2014.
3. J.E. McMurry, Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning Edition, 2013.
4. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2nd Edition, New Age International Publishers, 2010.
5. R.T. Morrison & R.N. Boyd, Organic Chemistry, Pearson, 2010.
6. A. Bahl, & B.S. Bahl, S. Chand, Advanced Organic Chemistry, 2010.
7. J.E. Huheey, E.A. Keiter, R.L. Keiter, & O.K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
8. E.L. Eliel, Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
9. F.A. Cotton, G. Wilkinson, & P.L. Gaus, Basic Inorganic Chemistry, 3rd Edition, Wiley, 1995.
10. J.D. Lee, Concise Inorganic Chemistry ELBS, 1991.
11. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi 1988.
12. Cotton, F.A., Wilkinson, G. & Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition, Wiley, 1995.
13. Finar, I.L. Organic Chemistry (Volume I & II), E.L.B.S.,1988.

Course No:	Course Name: GE-Lab: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons						Course Code: SBS CH 020102 GE 0042
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc.	**Semester:** I	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			0	0	4	2	**Total Hours: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** None
Course Objective	*To inculcate the common skills required for performing simple inorganic and organic chemistry practicals.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** The estimation techniques by volumetric analysis **CO2**: The handling skills of simple chemicals, glassware and small equipment. **CO3:** The qualitative analysis of simple organic compounds

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	***INORGANIC CHEMISTRY*** **VOLUMETRIC ANALYSIS** i. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. ii. Estimation of oxalic acid by titrating it with $KMnO_4$. iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$. iv. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator. v. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.	30
II	***ORGANIC CHEMISTRY*** **QUAILITATIVE ANALYSIS OF ORGANIC COMPOUNDS** i. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements). ii. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given) (a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.	30

	(b) Identify and separate the sugars present in the given mixture by paper chromatography.	

Suggested Readings:

1. G. Svehla, Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. J. Mendham, Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. A.I. Vogel, Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th Edition, 1996.
4. F.G. Mann, & B.C. Saunders, Practical Organic Chemistry Orient-Longman, 1960.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Chemical Energetics, Equilibria & Functional Organic Chemistry-I</td><td colspan="4">Course Code:
SBS CH 020103 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc.</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week:</td><td>04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.:</td><td>60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: None</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide basic knowledge of chemistry of aromatic hydrocarbons, alky and aryl halides, alcohols, phenols, ethers and carbonyl compounds. To provide basic understanding of chemical energetics, chemical equilibrium and ionic equilibria.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Basics of chemical energetics.
CO2: Basics of chemical equilibrium and ionic equilibria.
CO3: Chemistry of aromatic hydrocarbons, alky and aryl halides.
CO4: Chemistry of alcohols, phenols, ethers and carbonyl compounds.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
	PHYSICAL CHEMISTRY-1	
I	**CHEMICAL ENERGETICS** Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.	15
II	**CHEMICAL EQUILIBRIUM AND IONIC EQUILIBRIA:** Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.	15

	Ionic Equilibrium: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle	
	ORGANIC CHEMISTRY-2	
III	**AROMATIC HYDROCARBONS** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). **ALKYL AND ARYL HALIDES** Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.	15
IV	**ALCOHOLS, PHENOLS AND ETHERS (UPTO 5 CARBONS)** Alcohols: *Preparation:* Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. Ethers (aliphatic and aromatic): Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.	15

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
2. T.W. Graham Solomon, C.B. Fryhle, & S.A. Dnyder, Organic Chemistry, John Wiley & Sons, 2014.
3. J.E. McMurry, Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
4. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume II), 2nd Edition, New Age International Publishers, 2010.
5. S. M. Mukerji, S. P. Singh, K.P.Kapoor and R. Das, Organic Chemistry (Volume I), 2nd Edition, New Age International Publishers, 2010.
6. I.L. Finar, Organic Chemistry (Volume I & II), E.L.B.S.
7. R.T. Morrison, & R.N. Boyd, Organic Chemistry, Pearson, 2010.
8. A. Bahl, & B.S Bahl, S. Chand, Advanced Organic Chemistry, 2010.
9. J.C. Kotz, P.M Treichel, & J.R. Townsend, General Chemistry Cengage Learning India Pvt. Ltd., New Delhi, 2009.
10. G.M. Barrow, Physical Chemistry, Tata McGraw-Hill, 2007.
11. G.W. Castellan, Physical Chemistry, 4th Edition, Narosa, 2004.
12. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, 1988.
13. B.H Mahan, University Chemistry, 3rd Edition, Narosa, 1998.
14. R.H. Petrucci, General Chemistry, 5th Edition, Macmillan Publishing Co.: New York, 1985.

Course No:	Course Name: GE Lab: Chemical Energetics, Equilibria & Functional Organic Chemistry-I				Course Code: SBS CH 020104 GE 0042		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc.	**Semester:** I	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week: 04** **Total Hrs: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks		**Examination Duration: 6 Hrs.** **Pre-requisite of course:** None					

Course Objective	*To acquire the skills for handling reactions to prepare simple organic compounds. To provide knowledge about the purification techniques for organic compounds and their m.pt determination to the students. To explain the importance and applications of thermochemistry and to calculate the pH of the different solutions.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Thermochemistry and its applications in chemistry **CO2**: Ionic equilibria and measurement of pH of different solutions. **CO3:** Purification techniques and their importance **CO4:** Single-step organic preparations and purification of the obtained product

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**PHYSICAL CHEMISTRY** **Thermochemistry** 1. Determination of heat capacity of calorimeter for different volumes. 2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. 3. Determination of enthalpy of ionization of acetic acid. 4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl). 5. Determination of enthalpy of hydration of copper sulphate. 6. Study of the solubility of benzoic acid in water and determination of ΔH. **Ionic equilibria** pH measurements Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter. a) Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii)Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.	30
II	**ORGANIC CHEMISTRY** 1. Purification of organic compounds by crystallization (from water and alcohol) and distillation. 2. Criteria of Purity: Determination of melting and boiling points.	30

	3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done. (a) Bromination of Phenol/Aniline (b) Benzoylation of amines/phenols (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone	

Suggested Readings:

1. B.D. Khosla ; V. C. Garg & A. Gulati Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. A.L. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford & P.W.G. Smith Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
3. F.G. Mann & B.C. Saunders Practical Organic Chemistry Orient-Longman, 1960.

Course No:	Course Name: GE: Solutions, Phase Equilibria, Conductance, Electrochemistry & Functional Group Organic Chemistry-Ii					Course Code: SBS CH 020201 GE 4004		
Batch: 2022 Onwards	Programme: Integrated B.Sc.-M.Sc. Chemistry	Semester: II	L	T	P	Credit	Contact Hrs. per Week: 04	
			4	0	0	4	Total Hours: 60	

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** Basic understanding of solutions, phase equilibria, basic organic reactions.
Course Objective	*To provide students with basic concept of different types of binary solutions, phase equilibria , conductance, organic reactions.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Explain the concepts of different types of binary solutions-miscible, partially miscible and immiscible along with their applications **CO2**: Explain the thermodynamic aspects of equilibria between phases and draw phase diagrams of simple one component and two component systems **CO3**: Explain the factors that affect conductance, migration of ions and application of conductance measurement **CO4:** Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements **CO5:** Understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses **CO6:** Design newer synthetic routes for various organic compounds

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**SOLUTIONS AND PHASE EQUILIBRIA** **Solutions** Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. **Phase Equilibria**	15

	Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).	
II	**CONDUCTANCE AND ELECTROCHEMISTRY** **Conductance** Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid- base). **Electrochemistry** Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).	15
III	**CARBOXYLIC ACIDS AND THEIR DERIVATIVES, AMINES AND DIAZONIUM SALTS** **Carboxylic acids and their derivatives** Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. **Amines and Diazonium Salts** Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.	15
IV	**AMINO ACIDS, PEPTIDES AND PROTEINS, AND CARBOHYDRATES** **Amino Acids, Peptides and Proteins**	15

	Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of $-NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C- activating groups and Merrifield solid-phase synthesis. **Carbohydrates** Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.	

Suggested Readings:

1. Barrow, G. M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J. C., Treichel, P. M. & Townsend, J. R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B. H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
10. Berg, J. M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

Course No:	Course Name: GE Lab: Solutions, Phase Equilibria, Conductance, Electrochemistry & Functional Group Organic Chemistry-Ii						Course Code: SBS CH 020202 GE 0042
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.-M.Sc. Chemistry	**Semester:** II	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
			0	0	4	2	**Total Hrs: 60**

Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.
Course Objective	*To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Determine distribution constant **CO2**: Determine conductance **CO3:** Understand potentiometric titrations **CO4:** Determine qualitative organic analysis

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**PHYSICAL CHEMISTRY** **Distribution** Study of the equilibrium of one of the following reactions by the distribution method: $I2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$ $Cu^{2+}(aq) + xNH_2(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$ **Phase equilibria** a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature. **Conductance** (i) Determination of cell constant (ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid (iii) Perform the following conductometric titrations: (a) Strong acid vs. strong base and (b) Weak acid vs. strong base **Potentiometry** (i) Perform the following potentiometric titrations:	30

	(ii) Strong acid vs. strong base (iii) Weak acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt	
II	**ORGANIC CHEMISTRY** **I** Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative. **II** (i) Separation of amino acids by paper chromatography (ii) Determination of the concentration of glycine solution by formylation method (iii) Titration curve of glycine (iv) Action of salivary amylase on starch (v) Effect of temperature on the action of salivary amylase on starch (vi) Differentiation between a reducing and a nonreducing sugar	30

Suggested Readings:

1. Vogel, A. I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J.; Smith, P. W. G. *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th ed, 1996.
2. Mann, F. G.; Saunders, B. C. *Practical Organic Chemistry* Orient-Longman, 1960.
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V. K.; Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics</td><td colspan="3">Course Code:
SBS CH 020203 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022 Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>II</td><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand chemistry of d and f block elements
CO2: Properties of coordination compounds
CO3: Understanding VBT for bonding in coordination compounds
CO4: Understanding CFT for bonding in coordination compounds
CO5: Understand the real gases deviation from ideal behaviour
CO6: Define rate of reactions and the factors that affect the rates of chemical reactions.</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**TRANSITION ELEMENTS (3d SERIES)** General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).	**15**
II	**COORDINATION CHEMISTRY** Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.	**15**

	CRYSTAL FIELD THEORY Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.	
III	**KINETIC THEORY OF GASES** Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).	**15**
IV	**CHEMICAL KINETICS** The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).	**15**

Suggested Readings:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill, 2007.
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa, 2004.
3. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
4. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York, 1985.
5. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.
6. Atkins, P. Paula, J. Atkins' Physical Chemistry, 10th Edition. Oxford University Press, 2014.

<table>
<tr><td>Course No:</td><td colspan="2">Course Name:
GE Lab: Transition Metal & Coordination Chemistry, States of Matter & Chemical Kinetics</td><td colspan="6">Course Code:
SBS CH 020204 GE 0042</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td colspan="2">Contact Hrs. per Week: 04</td></tr>
<tr><td>II</td><td>0</td><td>0</td><td>4</td><td>2</td><td colspan="2">Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Basic understanding of transition metals, coordination chemistry, kinetic theory of gases and chemical kinetics.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various theories of reaction rates.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Analyze presence of acid and basic radicals
CO2: Determine hardness of water
CO3: Study reaction rates
CO4: Measurement of surface tension and viscosity</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

<table>
<tr><th>Unit No.</th><th>Contents</th><th>Contact Hrs.</th></tr>
<tr><td>I</td><td>INORGANIC CHEMISTRY
Semi-micro qualitative analysis (using H_2S or other methods) of mixtures - not more than two ionic species (one anion and one cation, excluding insoluble salts) out of the following:
Cations : NH^{4+}, Pb^{2+}, B^{i3+}, Cu^{2+}, Cd^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+
Anions : CO_3^{2-} , S^{2-}, SO_2^{-}, $S_2O_3^{2-}$, NO^{3-}, CH_3COO^-, Cl^-, Br^-, I^-, NO_3 , SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^-
(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.</td><td>30</td></tr>
<tr><td>II</td><td>PHYSICAL CHEMISTRY
(I) Surface tension measurement (use of organic solvents excluded).
a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
b) Study of the variation of surface tension of a detergent solution with concentration.
(II) Viscosity measurement (use of organic solvents excluded).
a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
(III) Chemical Kinetics
Study the kinetics of the following reactions.</td><td>30</td></tr>
</table>

	1. Initial rate method: Iodide-persulphate reaction 2. Integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid. 3. Saponification of ethyl acetate.	

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

<table>
<tr><td colspan="2">Course No:</td><td colspan="4">Course Name:
GE: Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy</td><td colspan="3">Course Code:
SBS CH 020301 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022 Onwards</td><td rowspan="2" colspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2" colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of 3d elements, bonding aspects in organometallic compounds along with some spectroscopic parameters.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide students with basic concept of bonding aspects in organometallic/bioinorganic/polynuclear compounds.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understand the chemistry and applications of 3d elements including their oxidation states and important properties of the familiar compounds potassium dichromate, potassium permanganate and potassium ferrocyanide
CO2: Use IR data to explain the extent of back bonding in carbonyl complexes
CO3: Get a general idea about role of metal ions present in biological systems
CO4: Understand the fundamentals of functional group chemistry, polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism
CO5: Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques
CO6: Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**CHEMISTRY OF 3*d* METALS AND ORGANOMETALLIC COMPOUNDS** **Chemistry of 3*d* metals** Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$. **Organometallic Compounds** Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-	15

	acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).	
II	**BIO-INORGANIC CHEMISTRY** A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).	**15**
III	**POLYNUCLEAR AND HETERONUCLEAR AROMATIC COMPOUNDS AND ACTIVE METHYLENE COMPOUNDS** **Polynuclear/heteronuclear aromatic compounds** Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. **Active methylene compounds:** *Preparation:* Claisen ester condensation. Keto-enol tautomerism. *Reactions:* Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).	**15**
IV	**APPLICATION OF SPECTROSCOPY TO SIMPLE ORGANIC MOLECULES** Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α,β – unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).	**15**

Suggested Readings:

1. Huheey, J. E.; Keiter, E.; Keiter, R. *Inorganic Chemistry: Principles of Structure and Reactivity,* Pearson Publication.
2. Miessler, G. L.; Tarr, D. A. *Inorganic Chemistry,* Pearson Publication.
3. Lee, J. D. *A New Concise Inorganic Chemistry,* E.L.B.S.
4. Cotton, F. A.; Wilkinson, G. *Basic Inorganic Chemistry*, John Wiley & Sons.
5. Finar, I. L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
6. Dyer, J. A. *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.
7. Silverstein, R. M.; Bassler, G. C.; Morrill, T. C. *Spectroscopic Identification of Organic Compounds*, John Wiley & Sons.
8. Morrison, R. T.; Boyd, R. N. *Organic Chemistry,* Prentice Hall.
9. Sykes, P. *A Guide Book to Mechanism* in *Organic Chemistry,* Orient Longman.
10. Bahl, A.; Bahl, B. S. *Advanced Organic Chemistry,* S. Chand.

<table>
<tr><td rowspan="1">Course No:</td><td colspan="3">Course Name:
GE Lab: Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons And UV, IR Spectroscopy</td><td colspan="4">Course Code:
SBS CH 020302 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td><td>Total Hrs: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 50
CIE: 15 Marks
TEE: 35 Marks</td><td colspan="5">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="5">Pre-requisite of course: Basic understanding of metal-carbon bonds, metal ions in biology, hydrocarbons and spectroscopy.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of transition/inner transition metals and bonding in coordination chemistry. Also get idea about various spectroscopic techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understanding of metal-carbon bond in chemistry
CO2: Importance of metal ions in biology
CO3: Understanding of enzymes and proteins
CO4: Synthesis of simple molecules
CO5: And their characterizations by UV and IR spectroscopy</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

<table>
<tr><td>Unit No.</td><td>Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td>INORGANIC CHEMISTRY

1. Separation of mixtures by chromatography: Measure the Rf value in each case. (Combination of two ions to be given)
Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or
Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}
2. Preparation of any two of the following complexes and measurement of their conductivity:
a. tetraamminecarbonatocobalt (III) nitrate
b. tetraamminecopper (II) sulphate
c. potassium trioxalatoferrate (III) trihydrate
Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.</td><td>30</td></tr>
<tr><td>II</td><td>ORGANIC CHEMISTRY

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative. Characterization by UV and IR spectroscopy.</td><td>30</td></tr>
</table>

Suggested Readings:

1. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

<table>
<tr><td>Course No:</td><td colspan="3">Course Name:
GE: Quantum Chemistry, Spectroscopy & Photochemistry</td><td colspan="4">Course Code:
SBS CH 020303 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of quantum mechanics, molecular spectroscopy and photochemical reactions.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of quantum mechanics, bonding in molecules, electronic transition, quantum efficiency and photochemical processes.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions
CO2: Understand chemical bonding in molecules
CO3: Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra
CO4: Understand the fundamentals of electron spin resonance
CO5: Understanding fundamental of photophysical phenomena
CO6: Define rate of reactions and the factors that affect the rates of chemical reactions.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**QUANTUM CHEMISTRY** Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.	15

II	**CHEMICAL BONDING** Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H^{2+}. Bonding and antibonding orbitals. Qualitative extension to H2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH2 type molecules.	15
III	**MOLECULAR SPECTROSCOPY** Interaction of electromagnetic radiation with molecules and various types of spectra; Born- Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.	15
IV	**PHOTOCHEMISTRY** Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.	15

Suggested Readings:

1. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4^{th} Ed. Tata McGraw-Hill: New Delhi, 2006.
2. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill, 2001.
3. House, J. E. *Fundamentals of Quantum Chemistry* 2^{nd} Ed. Elsevier: USA, 2004.
4. Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press, 2005.
5. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press, 2015.
6. Rohatgi, K. K. Mukherjee, K. K. Fundamentals of Photochemistry, 3^{rd} Edition. New Age International (P) Ltd., 2014.

<table>
<tr><td>Course No:</td><td colspan="5">Course Name:
GE Lab: Quantum Chemistry, Spectroscopy & Photochemistry</td><td colspan="3">Course Code:
SBS CH 020304 GE 0042</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td>Semester:

III</td><td>L

0</td><td>T

0</td><td>P

4</td><td>Credit

2</td><td colspan="2">Contact Hrs. per Week: 04
Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="7">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="7">Pre-requisite of course: Knowledge of spectroscopy and colourimetry</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide students with basic concept of quantum mechanics, bonding in molecules, electronic transition, quantum efficiency and photochemical processes.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions
CO2: Understand chemical bonding in molecules
CO3: Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra
CO4: Understand the fundamentals of electron spin resonance
CO5: Understanding fundamental of photophysical phenomena
CO6: Define rate of reactions and the factors that affect the rates of chemical reactions.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td colspan="9">NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.</td></tr>
<tr><td>Unit No.</td><td colspan="7">Contents</td><td>Contact Hrs.</td></tr>
<tr><td>I</td><td colspan="7">UV/VISIBLE SPECTROSCOPY
i) Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
ii) Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
iii) Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.</td><td>30</td></tr>
<tr><td>II</td><td colspan="7">COLOURIMETRY
i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7$ in a solution of unknown concentration
ii) Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
iii) Study the kinetics of iodination of propanone in acidic medium.
iv) Determine the amount of iron present in a sample using 1,10-phenathroline.
v) Determine the dissociation constant of an indicator (phenolphthalein).
vi) Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
vii) Analyse the given vibration-rotation spectrum of HCl(g)</td><td>30</td></tr>
</table>

Suggested Readings:

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Course No:	Course Name: GE: Molecules of Life				Course Code: SBS CH 020401 GE 4004		
Batch: 2022 Onwards	**Programme:** Integrated B.Sc.- M.Sc. Chemistry	**Semester:** **IV**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration: 3 Hrs.** **Pre-requisite of course:** Basic understanding of biological processes.					
Course Objective	*To provide students with basic concept of* biological processes and energy in biosystem.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses **CO2**: Gain an insight into mechanism of enzyme action and inhibition **CO3**: Understand the basic principles of drug-receptor interaction and SAR **CO4:** Understand biological processes like replication, transcription and translation **CO5:** Demonstrate an understanding of metabolic pathways, their inter-relationship, regulation and energy production from biochemical processes **CO6:** To understand concept of energy in biosystems						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**CARBOHYDRATES** Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.	**15**
II	**AMINO ACIDS, PEPTIDES AND PROTEINS** Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t- butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.	**15**

III	**ENZYMES AND CORRELATION WITH DRUG ACTION, AND NUCLEIC ACIDS** **Enzymes and correlation with drug action** Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non- competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group,-NH_2 group, double bond and aromatic ring. **Nucleic Acids** Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature)**, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.	15
IV	**LIPIDS AND CONCEPT OF ENERGY IN BIOSYSTEMS** **Lipids** Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). **Concept of Energy in Biosystems** Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.	15

Suggested Readings:

1. Morrison, R. T.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L.; Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
5. Berg, J. M. Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE Lab: Molecules of Life</td><td colspan="3">Course Code:
SBS CH 020402 GE 0042</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-
M.Sc. Chemistry</td><td>Semester:
IV</td><td>L
0</td><td>T
0</td><td>P
4</td><td>Credit
2</td><td>Contact Hrs. per Week: 04
Total Hrs: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic understanding of paper chromatography, saponification value, titration, synthesis and Extraction of DNA from onion/cauliflower.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of synthesis of medicinal compounds and paper chromatography. Also determination of saponification/concentration of some given sample.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand paper chromatography in separation of amino acids
CO2: Determine saponification value
CO3: To understand extraction of DNA
CO4: Synthesis of some medicinal compounds</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC CHEMISTRY** 1. Separation of amino acids by paper chromatography 2. To determine the concentration of glycine solution by formylation method. 3. Study of titration curve of glycine 4. Action of salivary amylase on starch 5. Effect of temperature on the action of salivary amylase on starch.	30
II	**ORGANIC CHEMISTRY** 1. To determine the saponification value of an oil/fat. 2. To determine the iodine value of an oil/fat 3. Differentiate between a reducing/nonreducing sugar. 4. Extraction of DNA from onion/cauliflower 5. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.	30

Suggested Readings:

1. Furniss, B. S.; Hannaford, A. J.; Rogers, V.; Smith, P. W. G.; Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
2. Ahluwalia, V. K.; Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE: Chemistry of Main Group Elements, Theories of Acids and Bases</td><td colspan="3">Course Code:
SBS CH 020403 GE 4004</td></tr>
<tr><td rowspan="2">Batch:
2022
Onwards</td><td rowspan="2">Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td rowspan="2">Semester:
IV</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td colspan="6">Pre-requisite of course: Basic properties of acid-base and s/p-block elements.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of periodic properties and bonding aspects in molecules.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand acid base interaction
CO2: Gain an insight into metallurgical processes
CO3: To understand the basic principles of periodic properties of s/p-block elements
CO4: To understand multicentre bonding in boranes
CO5: Understanding of inorganic polymers
CO6: To understand concept of pseudohalides</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**ACIDS AND BASES, GENERAL PRINCIPLES OF METALLURGY** **Acids and Bases** Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process. **General Principles of Metallurgy** Chief modes of occurrence of metals based on standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents. Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process.	15

II	**_s_- AND _p_-BLOCK ELEMENTS** Periodicity in _s_- and _p_-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling scale). General characteristics of _s_-block metals like density, melting and boiling points, flame colour and reducing nature. Oxidation states of _s_- and _p_-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy in C, P and S. Complex forming tendency of _s_ block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals. Solutions of alkali metals in liquid ammonia and their properties. Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of _s_-block metals.	**15**
III	**Structure, bonding and properties** Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH3), 14, 15, 16 and 17. Oxides of N and P, Oxoacids of P, S and Cl. Halides and oxohalides of P and S (PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2), Interhalogen compounds. A brief idea of pseudohalides	**15**
IV	**NOBLE GASES AND INORGANIC POLYMERS** **Noble gases** Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6 ,bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory. **Inorganic Polymers** Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in $(NPCl_2)_3$.	**15**

Suggested Readings:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F. A.; Wilkinson, G.; Gaus, P. L. Basic Inorganic Chemistry, 3rd ed. Wiley.
3. Douglas, B. E.; McDaniel, D. H.; Alexander, J. J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Greenwood, N. N.; Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
5. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
6. Miessler, G. L.; Tarr, D. A. Inorganic Chemistry 4th Ed. Pearson, 2010.
7. Atkin, P.; Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press 2010.

<table>
<tr><td>Course No:</td><td colspan="4">Course Name:
GE Lab: CHEMISTRY OF MAIN GROUP ELEMENTS, THEORIES OF ACIDS AND BASES</td><td colspan="3">Course Code:
SBS CH 020404 GE 0042</td></tr>
<tr><td>Batch:
2022
Onwards</td><td>Programme:
Integrated B.Sc.-M.Sc. Chemistry</td><td>Semester:

IV</td><td>L
0</td><td>T
0</td><td>P
4</td><td>Credit
2</td><td>Contact Hrs. per Week: 04
Total Hrs: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 50

CIE: 15 Marks

TEE: 35 Marks</td><td colspan="6">Examination Duration: 6 Hrs.

Pre-requisite of course: Basic understanding of quantitative analysis and synthesis of some inorganic complexes.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide students with basic concept of iodometric estimation, gravimetric estimation and determination of dissolved oxygen in water sample.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: To understand iodometric estimation
CO2: To understand gravimetric estimation
CO3: Determination of dissolved oxygen in water samples
CO4: Synthesis of some inorganic complexes</td></tr>
</table>

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC CHEMISTRY** 1.Iodometric estimation of potassium dichromate and copper sulphate 2.Iodimetric estimation of antimony in tartaremetic 3.Estimation of amount of available chlorine in bleaching powder and household bleaches 4. Estimation of iodine in iodized salts. 5. Iodimetric estimation of ascorbic acid in fruit juices.	30
II	**ORGANIC CHEMISTRY** 1. Estimation of dissolved oxygen in water samples. 2. Gravimetric estimation of sulphate as barium sulphate. 3. Gravimetric estimation of aluminium as oximato complex 4. Preparation of the following: potash alum, chrome alum, tetraamminecopper(II) sulphate monohydrate, potassium trioxalatoferrate(III) (any two, including one double salt and one complex).	30

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

5. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning
- Hands on training
- Self study analysis
- Report writing

6. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- Student-Centric Pedagogical Approach focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, may be adopted

7. ASSESSMENT AND EVALUATION

Overall assessment will be made as per relevant ordinances of CUH.

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired if required
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

8. REFERENCES

- **Instructional Template for Facilitating Implementation of Choice Based Credit System (CBCS) (https://www.ugc.ac.in/pdfnews/4426331_Instructional-Template.pdf)**
- **Scheme and Syllabi of B. Sc. Honours with chemistry (https://www.ugc.ac.in/pdfnews/6573215_B.Sc.HONOURS-CHEMISTRY.pdf)**
- **Scheme and Syllabi of B. Sc. with chemistry (https://www.ugc.ac.in/pdfnews/0614691_LOCF-chemistry.pdf)**
- **National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf**
- **The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==**
- **Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf**
- **Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions (https://www.ugc.ac.in/e-book/GL%20Multipe%20Entry%20Exit/mobile/index.html)**

9. APPENDICES

- **Curricular Reforms — Extracts from National Education Policy-2020**

Annexure I

To,

Date: 14-09-2022
Place: CUH, Mahendergarh

Head
Department of Chemistry
Central University of Haryana, Mahendergarh

From,

Dr. Anindita Chakraborty
Assistant Professor (INSPIRE FACULTY)
Department of Chemistry
Central University of Haryana, Mahendergarh

Sub: Request to do the needful for independent guidance of Ph.D. student to the DST INSPIRE Faculty

Dear Sir,

With reference to my request for allowing Ph.D. guidance to DST INSPIRE Faculty dated 25th August, 2022 and its subsequent proceedings (copy attached), I, Dr. Anindita Chakraborty, kindly request you to take the matter further and do the needful to include it in the CUH Ph.D. ordinance in the forthcoming Academic Council meeting so that I get the benefit at the earliest.

Following documents are attached for your convenience,

1. DST Award Letter *(Annexure 1)*
2. CUH Joining Letter *(Annexure 2)*
3. Proof of current co-guidance of Ph.D. student *(Annexure 3)*
4. DST INSPIRE Guidelines *(Annexure 4)*
5. CUH Ph.D. Ordinance (Page 1-4, *Annexure 5*)

Kindly note similar contractual positions such as UGC-FRP Faculty are also allowed to guide Ph.D. students solely *(Annexure 6)*.

In view of the above, I kindly request you to do the needful at your earliest convenience.

Sincerely yours,

Anindita
14/09/22

Dr. Anindita Chakraborty

Forwarded for n.a.
14/9/2022

Dean, SBS

Forwarded for n-a in the A.C. meeting
14/9/2022

Request and proceedings

Diary No. 333
Date: 30/08/2022
Dept. of Chemistry

CUH/Dean (Acad.)/188
02/09/2022

प्राप्ति डायरी No. 4145
Dated 02/09/22
08/09/22
Vice-Chancellor's Office, CUH

Department of Chemistry
Central University of Haryana

Date: 25.08.2022

Subject: Request for allowing independent Ph.D. guidance to DST INSPIRE Faculty, Dr. Anindita Chakraborty

The undersigned has been awarded DST INSPIRE FACULTY FELLOWSHIP for five years (DST Faculty Registration No.: IFA20-CH-331) and joined CUH on 15-09-2021 (DST award letter and CUH joining letter are attached, *Annexures 1 and 2*). At present, I am guiding a Ph.D. student as a co-supervisor (*Annexure 3*). The DST INSPIRE guideline has the provision of facilitating an INSPIRE fellow for independent Ph.D. guidance, however with the consent of the host institute (*Annexure 4*). In my case the host institute is CUH. However, as per the Ph.D. ordinance of CUH, only regular faculty members of the University can guide Ph.D. students independently (*Annexure 5*). "क"

I have completed my Ph.D. in 2016 and I have around three years of postdoctoral experience in the UK at the University of St. Andrews, University of Manchester and University of Sussex. I have been awarded a highly competitive international fellowship (Newton Fellowship from the Royal Society) during my postdoctoral tenure to work at the University of Manchester and University of Sussex. At present, I have completed almost one year of service at CUH. During this tenure, I have successfully guided M.Sc. Research Project of 04 students independently and acted as a co-supervisor of one Ph.D. student. At present, I believe I fulfil all the criteria for independently guiding a Ph.D. student.

In view of that, I kindly request you to allow me to guide a Ph.D. student independently which I believe is very important for my academic profile and progression.

Submitted for kind consideration and approval of Hon'ble Vice Chancellor.

Anindita
25/08/22
Dr. Anindita Chakraborty (PI)

HoD, Chemistry

Forwarded for n.a., please
25/8/2022

Hon'ble V.C.

उपरोक्त कार्य हेतु अधिष्ठाता अनुसंधान (DR) एवं अधिष्ठाता शैक्षणिक (DA) की सैद्धांतिक (in principle) संस्तुति है।

CUH Ph.D. Rule तथा Inspire faculty rule के conflict ("क") का समाधान आगामी AC Meeting (15/9) में Ph.D. Ordinance point 6.2 (Annexure V) में परिवर्तन कर किया जा सकता है।

Inspire faculty के Ph.D. supervisor बनने पर एक regular faculty को co-guide बनाकर अनिश्चितता की स्थिति में शोधकर्ता का कार्य आगे बढ़ाया जा सकता है।

उपरोक्त बिन्दुओं तथा CUH में प्रतिभावान युवा शिक्षकों को आकर्षित करने तथा उनकी मेधा का यथोचित विद्यार्थी हित, विश्वविद्यालय के राजस्व हित, NAAC/NIRF के हित में Ph.D. ordinance परिवर्तन की प्रबल संस्तुति सहित माननीय कुलपति महोदय से इसकी अनुमति की सादर प्रार्थना की जाती है।

DA
Dean - forward

T.K.
1/9/22

At present Co-supervisor possible. Ordinance to be changed for future.

माननीय कुलपति महोदय

T.K.
9/9/22

Dr. Anindita

Anindita

9/9/22

08/09/22
D.A.

Annexure 5

ORDINANCE- II (A)

DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.)

(Amended in accordance with the University Grants Commission (Minimum Standards and Procedure for Award of M.Phil./Ph.D. Degrees) (2nd amendment) Regulations, 2018)

1. Admission to Ph.D. Programme:

1.1 The student intake in each Department, shall be as per the availability of seats. Admission to the Ph.D. programme shall be made twice a year, preferably in the beginning of each semester.

1.2 All the available seats shall be notified 'category-wise' by the University, in advance.

1.3 Reservation of seats shall be notified in accordance with the latest guidelines, amended from time to time.

2. Eligibility:

A candidate shall be eligible for admission to the Ph.D. programme, if he/she possesses:

2.1 A Master's degree or a professional degree declared equivalent to the Master's degree by the corresponding statutory regulatory body, with at least 55% marks in aggregate or its equivalent grade 'B' in the UGC's 7-point scale (or an equivalent grade in a point scale wherever the grading system is followed), or an equivalent degree from a foreign educational Institution accredited by an Assessment and Accreditation Agency which is approved, recognized or authorised by an authority, established or incorporated under a law in its home country, or any other statutory authority in that country for the purpose of assessing, accrediting or assuring quality and standards of educational institutions.

2.2 A relaxation of 5% of marks, from 55% to 50%, or an equivalent relaxation of grade, may be allowed for the candidates belonging to SC/ST/OBC (non-creamy layer)/Differently-abled and other categories of candidates as per the decision of the University Grants Commission from time to time, or for those who had obtained their Master's degree prior to 19th September, 1991. The eligibility marks of 55% (or an equivalent grade in a point scale wherever the grading system is followed) and the relaxation of 5% to the categories mentioned above are permissible only on the basis of the qualifying marks without including the grace mark procedures.

2.3 The cases of candidates who have passed an examination outside the Indian Universities system and those who may not have obtained a Master's degree may be considered for admission to the programme subject to the condition that each case shall be examined on its own merit by the Admissions Committee and in accordance with the recommendations of the Equivalence Committee.

2.4 The candidates who have qualified the UGC/CSIR-JRF/NET/SLET/**GATE**, or are Teacher Fellowship-holders or have passed M. Phil. programme with course work recognised by

Anindita

the U.G.C., as per the UGC Regulations (Minimum Standards and Procedure for award of M.Phil./Ph.D. Degree, 2009), shall be exempted from appearing at the written test.

2.5 A candidate shall be eligible for admission to the part-time Ph.D. programme, if he/she fulfils the following conditions:

- The candidate should be working in an organization on regular basis.
- He/she meets the requisite minimum qualification for admission to Ph. D programme of the University.
- The candidate should have at least five years of continuous service.
- The candidate should furnish a "No Objection Certificate" from his/her organization in the prescribed format

3. Procedure for Admission:

3.1 Direct Admission:

3.1.1. The University shall conduct an Entrance Test, with the qualifying marks as 50% provided that a relaxation of 5 % of marks (from 50% to 45%) shall be allowed for the candidates belonging to SC/ST/OBC(Non-Creamy layers)/ Differently-abled category in the entrance examination conducted by the University.

Provided further that, if in spite of the above relaxation, the seats allotted for SC/ST/OBC(Non Creamy layer)/Differently-Abled categories remain unfilled, the University shall launch a Special Admission Drive, for that particular category within one month from the date of closure of admissions of General Category. The University will devise its own admission procedure, along with eligibility conditions to ensure that most of the seats under these categories are filled.

The syllabus for the Entrance Test shall consist of: (a). research methodology (50%) and (b). subject-specific (50%). The Entrance Test shall be conducted at the Centre(s) notified in advance by the University.

3.1.2. The admission shall be based on the performance of the qualified candidates in the interview/viva-voce to be organised by the Department concerned where the candidates shall be required to discuss their research interest/area through a presentation before a duly constituted Departmental Research Committee.

Provided that for selection of candidates, a weightage of 70% to the entrance test and 30% to the performance in the Interview/ viva-voce shall be given.

3.2 Integrated M.Phil.-Ph.D. Programme:

3.2.1. Admission to M.Phil./Ph.D. Integrated Programme shall be notified separately.

3.2.2. The Entry-level qualification for the M.Phil./Ph.D. Integrated Programme shall be the same as applicable as in the case of Direct admissions for the M.Phil. Programme of the University.

3.2.3. The students of the University who have successfully completed the M.Phil. Degree with CGPA of at least 5.5 shall be eligible to proceed to do research work leading to the Ph. D. Degree in an integrated programme. A relaxation of 0.5 grade points/ or equivalent, from 5.5 to 5.0, or an equivalent relaxation of grade, may be allowed for those belonging to SC/ST/OBC (non-creamy layer)/Differently-abled and other categories of candidates as per the decision of the UGC from time to time.

3.2.4. A student of this University whose M.Phil. dissertation has been evaluated and the viva voce is pending may be admitted to the Integrated Ph.D. programme of the University provisionally subject to the fulfilment of the requirement for admission within one month of the date of provisional admission.

4. Departmental Research Committee (DRC):

In each Department of the University, academic matters related to the Ph.D. programme shall be supervised by a Departmental Research Committee consisting of the following:

(i) Head of the Department: Chairman (ex-officio)

(ii) All the Professors of the Department: (ex-officio)

(iii) Associate Professors in the Department, subject to a maximum of two, by rotation according to seniority;

(iv) Two Assistant Professors in the Department, qualified to be Research (Ph.D.) Supervisor(s), by rotation according to seniority; and

(v) One external expert to be called by the Head of Department out of the panel drawn by the BoS.

Where a Department has a strength of less than ten teachers, all faculty members eligible to be Research (Ph.D.) Supervisors shall be members of the Departmental Research Committee. The term of the members of the Departmental Research Committee, except the ex-officio members, shall be for two years.

At least, 50% of the members shall be required to be present in the meeting to form the quorum, with the presence of the Chairman or his/her representative as mandatory.

Where no teacher in the Department is eligible to be the Head, the Teacher-in-charge, if eligible to be Research (Ph.D.) Supervisor, shall convene the meetings of the DRC, failing which the members of the DRC may elect one of the members present at the meeting as the Chairperson of the Committee for the said meeting.

5. Duration of Ph.D. Programme:

5.1 The Ph.D. programme shall be for a minimum duration of three years, including course work and a maximum of six years.

Anindita

5.2 The women candidates and Persons with Disability (more than 40% disability) may be allowed a relaxation of two years for the Ph.D. in the maximum duration. In addition, the women candidates may be provided Maternity Leave/Child-Care Leave once in the entire duration of the Ph.D. programme for up to 240 days.

6. Research Supervisor:

6.1 The School Board/BOS, on the recommendation of the DRC, may appoint any regular Professor of the University with at least five research publications in **UGC approved/** refereed journals, and any regular Associate/Assistant Professor of the University with a Ph.D. degree and at least two research publications in **UGC approved/** refereed journals, as a Research Supervisor.

6.2 Only a full-time regular teacher of the University can act as a Supervisor. No external supervisor is allowed. However, a Co-Supervisor can be allowed in inter-disciplinary areas from the same/other department(s) of the same institute or from any other related institution, with the approval of the Research Advisory Committee.

6.3 The allocation of Research Supervisor for a selected research scholar shall be decided by the School Board/BOS on the recommendation of the DRC concerned, depending on the number of scholars per Research Supervisor, the available specialization among the Supervisors and research interests of the scholars as indicated by them at the time of interview/viva voce.

6.4 In the case of the topics which are of inter-disciplinary nature, where the Department concerned feels that the expertise in the Department has to be supplemented from outside, the D.R.C. may appoint a Research Supervisor from the Department itself, who shall be known as the Research Supervisor, and a Co-Supervisor from outside the Department/ School/Institution, on such terms and conditions as may be specified and agreed upon by the consenting Institutions.

6.5 A Research Supervisor/Co-supervisor who is a Professor, at any given point of time, cannot guide more than eight (8) Ph.D. scholars. An Associate Professor as Research Supervisor can guide up to a maximum of six (6) Ph.D. scholars; and an Assistant Professor as Research Supervisor can guide up to a maximum of four (4) Ph.D. scholars.

6.6 In case of relocation of a female Ph.D. scholar due to her marriage or otherwise, the research data shall be allowed to be transferred to the University to which the scholar intends to relocate provided all the other conditions are followed in letter and spirit and the research work does not pertain to the project secured by the parent institution/ supervisor from any funding agency. The scholar shall, however, give due credit to the parent guide and the institution for the part of research already done.

6.7 In cases where a teacher is retiring or leaving and where redistribution/reallocation of the Ph.D. students is required for the abovementioned or any other reason, the Ph. D. students shall be adjusted among the eligible existing teachers of the department by relaxing the norms by the Departmental Research Committee (DRC)/Board of Studies (BOS).

Annexure 6

UNIVERSITY GRANTS COMMISSION
BAHADURSHAH ZAFAR MARG
NEW DELHI-110 002

BY SPEED POST

No.F.4-5/2013(BSR)Pt.I July, 2017

19 4 JUL 2017

The Registrar of 43 Universities,
(As per the list attached)

Subject : **Academic and Administrative facilities to the selectees under the scheme of Faculty Recharge Programme-Regarding.**

Sir/Madam,

I am directed to inform you that as per the Pay Fixation Committee recommendations the UGC-FRP selectees placed in different Universities are entitled for all the emoluments or allowances / facilities at par with the teachers in Central Universities viz. DA, HRA, Children Education Allowances (CEA), Transport Allowances (TA), Medical Reimbursement as per CSMA rules, LTC and Special Duety Allowances @ 12.5% of Basic Pay + Grade Pay (for those faculties posted in North-Eastern Region including Sikkim. The faculties are also entitled to opt the New Pension Scheme (NPS) @ 10% pf Basic Pay + Grade Pay. The UGC faculty is also eligible for supervising of Ph.D. (M.Phil) thesis solely.

In addition, for the faculty on deputation in UGC-FRP, their leave salary and pension contributional should be remitted by the host University to their respective parent Institution which will be reimbursed by the UGC on actual basis.

You are requested to pay the Salary to the UGC faculties on time, which can be reimbursed later by the UGC.

You are therefore requested to adhere to the MoU signed by the University for availing FRP and provided all academic administration, co-curricular facilities at their respective places by the host University at par with their own permanent Faculty as per the Service Rules of the Scheme.

Yours faithfully,

(Shalini)
Education Officer

ISSUED

Anindita

Annexure # 4

Guidelines for INSPIRE Faculty Fellowship Scheme

The Department of Science and Technology, Government of India, launched the "Innovation in Science Pursuit for Inspired Research (INSPIRE)" [www.online-inspire.gov.in] Programme in 2008. This programme which covers the age group of 15-37 years, aims to attract young talent towards study of science leading to careers in research. INSPIRE includes multiple components out of which the INSPIRE Faculty Fellowship Scheme offers post-doctoral fellowships to young achievers with an opportunity for independent research in the near term to emerge as a future leader in the long term.

A) Purpose

1. To provide attractive opportunities to young achievers for developing independent scientific profiles and launch them towards fulfilling long-term careers.

2. To augment high-quality scientific manpower in scientific and educational institutions, especially the Central and State universities.

3. While vertical migration from the other INSPIRE components would be encouraged, this Scheme would also provide opportunity to meritorious candidates for lateral entry into the component.

4. This scheme provides an opportunity to post-doctoral fellows for carrying out independent research however does not guarantee a regular position after 5 years.

B) Eligibility

Essential

1. Indian citizens and people of Indian origin with PIO status having PhD degree (in science, mathematics, engineering, pharmacy, medicine and agriculture related subjects) from any recognized university in the world.

2. Candidates should possess a minimum of 60% (or equivalent CGPA) marks throughout their academic profile starting from the Higher Secondary Examination (Class 12 onwards).

3. Those that have submitted their PhD theses and are awaiting the award of degree shall also be eligible. However, selection for the Fellowship will be confirmed only after the PhD degree is awarded.

4. The upper age limit as on 1st January 2021, is 32 years for General Category. However, for SC, ST and Women candidates, the upper age limit will be 37 years. For persons with benchmark disabilities (Divyangjan with not less than 40 percent of a specified disability), the upper age limit will be 42 years.

5. Publication(s) in highly reputed journals demonstrating outstanding research potential of the candidate.

Anindita

6. Candidates who are employed in regular/contractual positions within India may also apply for INSPIRE Faculty Fellowship for improvement and enhancement in their career prospects but, upon selection, the candidates will need to resign (no lien or deputation or any type of leave would be accepted) from the current job and organization before taking up the INSPIRE Faculty Fellowship. The candidates, who get selected for regular position in any institute/university after submission of IFF application, would be entitled to receive the Research Grant only as INSPIRE Faculty Fellows.

Desirable

7. Candidates who are within top 1% in Class 12 examination, IIT-JEE rank holders, 1st rank holders either in graduation or post-graduation level university examinations.

C) Mode of Application

1. Eligible candidates need to submit applications ONLINE through the portal of INSPIRE programme only. No other mode of submission of the application is permitted.

2. To apply ONLINE, please visit the website: www.online-inspire.gov.in and follow the process described therein. After successful submission of the application online, the candidate may obtain a printout of the application and keep it for his/her personal reference.

D) Method of Selection

1. The Indian National Science Academy (INSA), New Delhi, in coordination with DST, is implementing this INSPIRE Faculty Fellowship Scheme up to the stage of recommendation of candidates for INSPIRE Faculty Fellowship.

2. A three-tier selections process, viz. evaluation by discipline-based Expert Committees (INSA), followed by the recommendations of Apex Level Committee (INSA) and INSPIRE Faculty Award Council (DST). Based on the recommendations of these Committees, DST makes the final selection.

E) Amount and Duration of INSPIRE Faculty Fellowship

1. Each selected INSPIRE Faculty Fellow will be eligible to receive a consolidated amount of Rs.1,25,000/- per month as fellowship. In addition, a Research Grant of Rs.7.0 lakh every year for 5 years will also be provided to each successful candidate including the carry-forward amount, if any, from the previous year. The consolidated amount of Rs.1,25,000/- per month is an all-inclusive fellowship and taxable as per the Indian IT Act.

2. The INSPIRE Faculty Fellowship is for a maximum period of 5 (five) years. No Fellow shall avail two fellowships concurrently during the tenure of this Fellowship period.

F) Issue of Offer Letter

1. The INSPIRE Faculty Fellowship Offer Letter is issued through the web portal (www.online-inspire.gov.in).

2. Selected candidates, who have not identified host institutions at the application stage, should do so immediately after their final selection. Selected candidates should avail the INSPIRE Faculty Fellowship within 3 months of issue of the Offer Letter. Otherwise, the Offer may get forfeited.

3. A selected candidate, who is yet to be awarded the PhD degree, will receive intimation for submission of his/her PhD degree certificate within 3 months to avoid forfeiting the opportunity. Upon submission of the PhD degree certificate, the Offer Letter will be issued to the candidate through web portal with 3 months' validity to undertake the fellowship at the chosen Host Institution.

4. Selected candidates are advised not to choose the Institution from where they have obtained their PhD degree / done their PhD work or done post-doctoral work, if any.

5. Selected INSPIRE Faculty Fellows joining private academic/research institutes shall receive only the Research Grant and their host institutions will have to pay the fellowship amount as per Scheme norms.

G) Terms and Conditions for Implementation

1. The date of joining the Inspire Faculty Fellowship in the host institute would be considered as date of start of Fellowship.

2. A provision exists for supporting a research staff out of the Research Grant during the Fellowship tenure of 5 years as per host institution's guidelines. In the event of getting employment elsewhere in the country other than the Host Institute, the Fellow will also be allowed to move the research student, equipment, consumables etc., along with him/her to the new Host Institute with prior consent of both the institutions.

3. The annual Research Grant of @ Rs.7 lakh every year (100%) including carry-forward amount, if any, from previous years shall be utilized for incurring expenditure under all recurring and non-recurring budget heads like Manpower Cost, Consumables, Chemicals, Equipment. The amount under Travel, Contingencies and Overhead Charges will be limited to 10% (i.e. Rs.70,000/- per year), 10% (i.e. Rs.70,000/- per year) and 5% (i.e.Rs.35,000/- per year), respectively.

4. Every Faculty Fellow needs to provide a budget proposal with detailed break-up as above for utilization of the Research Grant to DST-INSPIRE Programme Division along with joining documents. The Fellow and the Host Institution need to adhere to the approved break-up over the entire duration of 5 years.

5. In case Fellows who have joined the Indian host institution leave/quit the Scheme pre-maturely within 6 months of his/her joining, he/she needs to forego his/her Fellowship as well as the Research Grant amount for the said duration.

6. Fellows will be eligible to undertake visits to any international Laboratory/ University/ Institute for further exposure and training and to carry out research activities up to a maximum period of 18 months in multiple slots during the 5 years of fellowship. The application to visit countries abroad will be considered only after availing 12 months of INSPIRE Faculty Fellowship tenure and the visit should preferably to a place other than his or her PhD/post-doctoral place. This period will be treated as part of the Fellowship period. In the event of receiving sustenance allowance from the visiting Institute/ University/ Laboratory, the Faculty fellow may not be eligible for availing the Fellowship amount during the visit period.

7. Fellows will be required to visit the web portal for submitting the annual financial documents and Annual Progress Report to the DST-INSPIRE Programme Division. Mid-term/periodic performance evaluation will be done by national-level Expert Committees. Participation in the performance evaluation is mandatory and continuation of support to any Fellow shall depend upon the performance assessment by the Expert Committees.

8. Fellows shall administratively be governed by the prevailing rules and regulations of the Host Institution, especially regarding all types of leave and other administrative matters. There will be no separate rules provided by DST-INSPIRE.

9. Fellows are required to take prior approval of host institution for short term visit up to 8 weeks/2months for attending conference/training/seminar/collaborative research work etc. in country or abroad and inform DST. Visits to undertake scientific work for more than 8 weeks would require prior permission from DST.

10. In case an INSPIRE Faculty Fellow finds a permanent position during the tenure of the Fellowship, the fellowship amount shall be discontinued from the day the INSPIRE Faculty Fellow joins the permanent position but he/she may continue with the INSPIRE Faculty Fellowship Scheme availing Research Grant only for the remaining period to carry out research while occupying the new position.

11. The INSPIRE Faculty Fellow is eligible to apply for any competitive grant from various funding agencies during the tenure of the INSPIRE Faculty Fellowship.

H) Transfer or Change of Host Institution (including absorption)

1. Transfer or Change of Host Institution is permissible under the Scheme either upon getting i) permanent employment in another Institution; ii) or for any other valid reason.

2. In all such cases, the Faculty Fellow needs to inform the DST-INSPIRE Programme Division immediately with the following documents to effect the change and smooth facilitation of transfer of funds etc.

- Appointment Letter of permanent employment or justification for change of Host Institution.
- NOC from the present Host Institute and Acceptance Letter from the new Host Institute.
- Joining Letter from the new Host Institute due to transfer or permanent employment (either same or different Host Institution),
- Fresh signed copy of the Undertaking (not required in case of permanent employment in the same Host Institution),
- Up-to-date financial documents from the present Host Institute (also in case of permanent employment in the same Host Institute).

I) Role and requirements of Host Institutions

1. Host institutions are expected to provide congenial atmosphere to INSPIRE Faculty Fellows to enable them to excel in their work, and should view them as potential assets for faculty development. It is desirable if the host institutes introduce new areas/directions of research through this Scheme.

2. Under no circumstances the "INSPIRE Faculty Fellowship" is renewable after 5 years. Host institutions are expected to consider the "INSPIRE Faculty Fellows" for permanent positions in due course, subject to their meeting institutional performance assessment criteria.

3. Host institutes should provide acceptable laboratory and office space (independently or on shared basis), ensure access to all common infrastructural facilities, computing facilities, library etc., to the INSPIRE Faculty Fellows. Host institutions are expected to encourage INSPIRE Faculty Fellows to publish high quality research as first/corresponding author in the list of researchers.

4. Host institutes should provide information on whether the INSPIRE Faculty Fellow will be allowed to supervise PhD students, hire research fellows, independently or jointly with a permanent faculty member, while hosting the Faculty Fellows.

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Anindita

Annexure 1

GOVERNMENT OF INDIA
MINISTRY OF SCIENCE & TECHNOLOGY
Department of Science & Technology
Technology Bhavan, New Mehrauli Road
New Delhi - 110016

inspire

Faculty Registration No. : **IFA20-CH-331**
Date: 13 July, 2021

Subject: INSPIRE Faculty Fellowship - Offer letter[DST/INSPIRE/04/2020/001603]

Dear Dr. Anindita Chakraborty

1. The Government of India has launched a unique scheme "Innovation in Science Pursuit for Inspired Research(INSPIRE)" with several components. INSPIRE Faculty Fellowship Scheme is one such component of the INSPIRE Programme which offers a contractual research award for carrying out independent research to young achievers. Based on your application followed by the due selection process, I am pleased to inform you that you have been selected for INSPIRE Faculty Fellowship.
2. A consolidated Faculty fellowship amount of Rs.1,25,000/- per month with annual increment of Rs.2000/- along with Rs.35,00,000/- of research grant (@ Rs.7 Lakhs/year)for five years shall be offered to each Awardee. The offer is tenable for a period of five years only from the date of joining the Faculty position. There will be no further extension of this offer beyond 5 years and this offer does not provide any assurance or guarantee to provide regular job to any candidate. Moreover, each candidate, as well as the Host Institute, will be required to sign an 'UNDERTAKING' for implementation of this Faculty Fellowship offer. Current Guidelines and all formats for joining under the INSPIRE Faculty Fellowship scheme is available at the web portal http://www.online-inspire.gov.in
3. Each candidate will be required to inform DST on acceptance of the offer within 3 months from the date of this offer. This includes the finalization of the Host Institute for implementation of this offer and joining the selected Host Institute. In case the candidate does not inform DST within 3 months, the offer shall automatically be forfeited.
4. The selected INSPIRE Faculty fellows, in case of their joining in private academic/research institutes, will receive only Research Grant and their respective host institute/University has to pay the fellowship amount equal to the scheme norms.
5. Please note that the Host Institution shall be other than the Institute/ University/ Laboratory where you have completed your Ph.D. work/degree. No requests on this matter will be entertained by DST.
6. Candidates who are presently living abroad may invariably try to join an Indian host institution within the stipulated time. No undue request for extension of joining time will be entertained by DST.
7. You are requested to take the necessary action towards implementing this offer. Towards this the following documents are required to upload at the portal (www.online-inspire.gov.in), so that necessary funds can be released to Host Institute from our end:
   i) Details of Bank Account of the Host Institute (not of the individual candidate). (Candidates are advised to select the respective host institute bank details from the drop-down menu of the portal database and not to add multiple entries in the portal)
   ii) Duly signed 'UNDERTAKING'
   iii) Year-Wise Budget Estimate for Research Grant of Rs.7,00,000/- each year (year-wise without clubbing)-For information only.
   iv) Joining Report (Duly authenticated)
8. Login-ID and Password used at the time of submission of application shall be used now as well for upload. Without submission of these documents online, no action would be possible to take at our end.
9. This issue's with the approval of Secretary DST vide Dy.No.E29771 dated 06/30/2021. We shall be looking for your responses in this respect.
10. Please quote the **Faculty Registration number** for future correspondence and hereinafter all communications by the awardees should be addressed to DST only and **not to INSA**. Any communications to INSA will go unattended and will be ignored.
11. Those who are not working, in any regular position in the chosen host institution for implementation of the INSPIRE Faculty fellowship scheme, are requested **not to fill** the "Placement Details" in the online portal.
12. All documents including the joining documents need to be uploaded **only in the online portal**. No hard copy of any document is required to be sent to the program division.

With Best Regards,

Dr. Bipin Joshi, Scientist. F
INSPIRE Program
E.mail: bipin.joshi@nic.in
Phone: 011-26590214

To,
Dr. Anindita Chakraborty [DST/INSPIRE/04/2020/001603]
Indira Nagar, Block 3, 15 Nilganj Road, Sodepur 700110, West Bengal
North 24 Parganas - 700110
WEST BENGAL .

This is computer generated document and does not require any signature. Incase of any discrepancy please contact Program Division

Anindita

Annexure 2

INSPIRE Faculty Fellowship- Joining Report

To

Head,
INSPIRE Program Division
Department of Science and Technology,
Technology Bhavan,
New Mehruali Road
New Delhi-16.

Subject: Acceptance of INSPIRE Faculty Fellowship Offer.

Dear Sir,

This has reference to the communication about my selection for the award of INSPIRE Faculty Fellowship (Ref no: DST/INSPIRE/04/2020/001603 dated 13 July 2021). I hereby accepts the offer under the terms and conditions of INSPIRE Faculty Fellowship of Department of Science and Technology.

*1. I will like to avail both the fellowship amount and research grant at Department of Chemistry Central University of Haryana (name of the department/institute) situated in Mahendergarh-123031, Haryana (Institute Address).

OR

2. I have been appointed in the institute/Univ.(Name) in India as ____________ w.e.f ____________ and would like to avail only research grant at ____________ (Name of department/Institute) situated in ____________ (Address)

(* Please tick the relevant para as applicable)

Thanking You,

Yours Faithfully,

Name: Dr. ANINDITA CHAKRABORTY
Anindita Chakraborty
15/09/2021
(Name & Signature of the Fellow)

Anindita

Forwarded by (To be forwarded by Registrar/ Vice- Chancellor/ Director only)

* 1. Institute has accepted to host Dr. Anindita Chakraborty as INSPIRE Faculty Fellow.

He/She has accepted the fellowship as above and he/she has not been appointed to any post at our institute/University at present. We will host him/her, as INSPIRE Faculty Fellow from (date 15/09/2021) as per the terms and conditions laid down in the Undertaking.

OR

2. Dr.-------------------------------has been appointed to the post of______w.e.f__at our institute/University at present. We will host him/her to avail Research grant only under INSPIRE Faculty Fellowship with salary from institute.

(* Please tick the relevant para as applicable)

16/9/21

Signature & Seal of the Head of the Institute

(Registrar/ Vice- Chancellor/ Director)

कुलसचिव/Registrar
हरियाणा केंद्रीय विश्वविद्यालय
Central University of Haryana
महेन्द्रगढ़, हरियाणा – 123029
Mahendergarh, Haryana - 123029

13/09/21

Anindita

Annexure 3

DEPARTMENT OF CHEMISTRY / रसायन विज्ञान विभाग
SCHOOL OF BASIC SCIENECS / मौलिक विज्ञान पीठ
CENTRAL UNIVERSITY OF HARYANA / हरियाणा केंद्रीय विश्वविद्यालय
Mahendergarh, Haryana 123031 / महेंद्रगढ़, हरियाणा 123031

Dated: 16-02-2022

Minutes of the Meeting of Departmental Research Committee (DRC)

A meeting of the Departmental Research Committee (DRC) of the Department of Chemistry, School of Basic Sciences, Central University of Haryana (CUH) was convened in the office of Head, Department of Chemistry on 16-02-2022 (Wednesday) at 10:00 A.M. onwards.

The following members were present in the meeting:

- Dr. Azaj Ansari, Assistant Professor
- Dr. Prakash Kanoo, Assistant Professor
- Dr. Rajeev S. Menon, Assistant Professor
- Dr. Manoj K. Gupta, Assistant Professor
- Dr. Amit Kumar, Assistant Professor
- Prof. Kalpana Chauhan
- Prof. Harish Kumar
- Prof. Vinod Kumar (Head, Department of Chemistry & Chairman of DRC)
- Prof. Pawan K. Sharma (External Expert Member), Department of Chemistry, Kurukshetra University, Kurukshetra

The following agenda items were deliberated and resolved in the meeting.

1) **Agenda item-1:** Consideration and recommendation of panel of external examiners for evaluating Ph.D. thesis of Ms. Monika (Roll No 10816).

   Recommendation of DRC:
   The panel of examiners for the evaluation of Ph.D. thesis of Ms. Monika (Roll No. 10816, 2017 admission) as proposed by the research supervisor Dr. Azaj Ansari attached as **Annexure-I** was considered and approved eight names for forwarding to the COE in sealed cover.

2) **Agenda item-2:** Consideration and recommendation of panel of external examiners for evaluating Ph.D. thesis of Ms. Eqvinshi (Roll No 10817).

   Recommendation of DRC:
   The panel of examiners for the evaluation of Ph.D. thesis of Ms. Eqvinshi (Roll No. 10817, 2017 admission) as proposed by the research supervisor Dr. Manoj K. Gupta attached as **Annexure-II** was considered and approved eight names for forwarding to the COE in sealed cover.

3) **Agenda item-3:** Consideration and approval of minutes of Research Advisory Committee (RAC) for assigning new area of research/topics to Mr. Aman Kumar (Roll No. 190592) and Ms. Pragati Yadav (Roll No. 190596) for their Ph.D. thesis.

Prakash Gupta 16/02/22 16/2/2022 Rajeev
16/02/22 16/02/22 Azaj Ansari

Recommendation of DRC:

The DRC considered and approved the recommendations of Research Advisory Committee **Annexures III and IV)** of following students.

Student name & Roll Number	Supervisor	Proposed Broad Area of Research (Broad topic)	Recommended Broad Area of Research by RAC (Broad topic)*	Specific observations for each student
Mr. Aman Kumar (190592)	Prof. Vinod Kumar, CUH	Synthesis, characterization and Biological Evaluation of Thiazole and Pyrazole Derivatives	Synthesis, Characterization and Biological Evaluation of Thiazole and Pyrazole Derivatives	-
Ms. Pragati Yadav (190596)	Prof. Vinod Kumar, CUH	Synthesis, Characterization and Applications of Pyrazole Derivatives	Synthesis, Characterization and Applications of Pyrazole Derivatives	-

*Title of thesis would be finalized at the time of pre-submission seminar.

4) **Agenda item-4:** Consideration and approval of minutes of Research Advisory Committee (RAC) for assigning the Co-Supervisor to Ms. Jyoti (Roll No. 200564) and Ms. Jyoti Rajput (Roll No. 200565) for their Ph.D. thesis.

Recommendation of DRC:

The DRC has considered and approved the recommendation of RAC (**Annexures V and VI**) for assigning co-supervisors to the following Ph.D. students.

Student name & Roll Number	Supervisor	Recommended Co-supervisor	Broad Area of Research (Broad topic)	Specific observations for each student
Ms. Jyoti (200564)	Prof. Vinod Kumar, CUH	Dr. Anindita Chakraborty, CUH	Chemistry of Metal-organic frameworks	-
Ms. Jyoti Rajput (200565)	Prof. Kalpana Chauhan, CUH	Dr. Vineet Kumar, Scientist-G, Forest Research Institute, Dehradun	Derivatization of guar gum using multifunctional reagents for biomedical applications	-

5) **Agenda item-5:** Consideration and approval of RAC minutes of Ph.D. students of Department of Chemistry

Recommendation of DRC: The RAC minutes of the following students related to their research progress were considered and approved by DRC. Details are provided in the table below.

Anindita

Azey Ansari

Name and Roll No.	Name of Supervisor	Date of RAC Meetings	Annexures	Recommendation of DRC
Eqvinshi, (10817)	Dr. Manoj K. Gupta	13-01-2022	Annexure-VII	Approved as proposed
Sharol Sebastian, (190602)	Dr. Manoj K. Gupta	15-02-2022 (2nd)	Annexure-VIII	Approved as proposed
Pratima Kumari, (190597)	Prof. Vinod Kumar	26-08-2021 (1st) 10-02-2022 (2nd)	Annexure-IX Annexure-X	Approved as proposed
Manshu Choudhary (200566)	Prof. Vinod Kumar	10-02-2022 (1st)	Annexure-XI	Approved as proposed
Pragati Yadav (190596)	Prof. Vinod Kumar	09-02-2022 (1st)	Annexure-IV	Approved as proposed
Aman Kumar (190592)	Prof. Vinod Kumar	09-02-2022 (1st)	Annexure-III	Approved as proposed
Jyoti (200564)	Prof. Vinod Kumar	14-02-2022 (1st)	Annexure-V	Approved as proposed
Antim (200561)	Dr. Amit Kumar	15-02-2022 (1st)	Annexure-XII	Approved as proposed
Sarita (190600)	Prof. Kalpana Chauhan	13-10-2021	Annexure-XIII	Approved as proposed
Oval Yadav (8844)	Dr. Azaj Ansari	04-02-2022	Annexure-XIV	Approved as proposed
Jyoti Rajput (200565)	Prof. Kalpana Chauhan	15-02-2022	Annexure-VI	Approved as proposed
Preety Yadav (180301)	Dr. Prakash Kanoo	10-02-2022	Annexure-XV	Approved as proposed
Ankita Yadav (195093)	Prof. Harish Kumar	29-12-2021	Annexure-XVI	Approved as proposed
Rajni (195093)	Prof. Harish Kumar	29-12-2021	Annexure-XVII	Approved as proposed
Sujata Negi (190603)	Prof. Kalpana Chauhan	10-02-2022	Annexure-XVIII	Approved as proposed

The meeting ended with thanks to the chair.

Azaj Ansari 16/02/2022
Dr. Azaj Ansari

16.02.2022
Dr. Prakash Kanoo

16/2/22
Dr. Rajeev S. Menon

Gupta 16/02/22
Dr. Manoj K. Gupta

16/2/2022
Dr. Amit Kumar

16/02/22
Prof. Kalpana Chauhan

16/02/22
Prof. Harish Kumar

16/2/2022
Prof. Vinod Kumar

16/2/2022
Prof. Pawan K. Sharma
(External Expert Member)

Anindita

Annexure – I

Annexure-XIII

सांख्यिकी विभाग

Department of Statistics

केंद्रीय विश्वविद्यालय हरियाणा, महेंद्रगढ़

Central University of Haryana, Mahendergarh

Minutes of the Meeting of Board of Studies (BOS)

The meeting of the Board of Studies (BOS) was held on May 10, 2022, at 3:00 P.M. onwards in the Office of the Head, Department of Statistics via the hybrid mode (Offline and Online both Modes). For the online mode, the Google meet link used is meet.google.com/drt-okiy-pdf.

The following persons were present in the meeting:

1. Prof. Vinod Kumar, **Chairperson**, Department of Statistics, CUH - offline
2. Dr. Anil Kumar, Principal Scientist, and Head, Division of Design of Experiments, ISARI, PUSA, New Delhi (**Subject Expert**) -**online**
3. Prof. Sangeeta Chopra, Department of Statistics, Panjab University, Chandigarh (**Subject Expert**) - **online**
4. Dr. Devendra Kumar, Department of Statistics, CUH, (TIC, Special Invitee) - offline
5. Dr. Manoj Kumar, Department of Statistics, Member, CUH- offline

First of all, the Chairperson of the BoS welcomed all the members of the Board of Studies, and then following agenda items were discussed in detail:

Agenda item 1: To confirm the minutes of the BOS meeting which was held on March 15, 2022.

Agenda item 2: To get approval for changing the instructions in the course for setting the question papers.

Agenda item 3: To get approval of M.Sc. Data Science scheme and contents of the course to effective from academic year 2022-2023.

Agenda item 4: To get approval of the syllabus of Ph.D. Statistics scheme and contents of the course to effective from academic year 2022-2023.

Any other issue with the permission with the chair.

After thorough discussion, the following have been resolved:

Agenda item 1: The minutes of the BOS meeting which was held on March 15, 2022, have been confirmed (Attached as Annexure-I).

Agenda item 2: Due to prevailing COVID 19 situation and in order to offer the flexibility for setting the question papers, the following instructions were given in all courses. **"Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal**

marks. Unit I will be taught via online mode". Now the same is deleted and new instructions are incorporated for setting the question papers. The instructions are: "**Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks. Question no. 2 to 5 have three parts and students need to answer any two parts of each question. Each part carries seven marks**". (Attached as Annexure-II)

Agenda item 3: The syllabus of M.Sc. Data Science scheme and contents of the courses have been approved and the same may be effective from academic year 2022-2023. (Attached as Annexure-III).

Agenda item 4: The syllabus of Ph.D. Statistics scheme and contents of the courses have been approved and the same may be effective from academic year 2022-2023. (Attached as Annexure-IV) .

Any other topic with permission of the chair.

There was no other agenda.

The meeting ended with a vote of thanks to the Chair.

10/5/22

(Prof. Vinod Kumar)
Offline Mode

(Dr. Anil Kumar)
Online Mode

(Prof. Sangeeta Chopra)
Online Mode

10.05.2022

(Dr. Devendra Kumar)
TIC, Special Invitee
Offline Mode

Manoj Kumar 10/5/22

(Dr. Manoj Kumar)
Offline Mode

HOD Statistics <hodstatistics@cuh.ac.in>

Minutes of BOS for your kind consideration and approval

3 messages

HOD Statistics <hodstatistics@cuh.ac.in> 10 May 2022 at 17:59
To: sarora131@gmail.com, K Chikara Anil <akumarchi72@gmail.com>

Dear Sir/ Madam
Please find attached herewith Minutes of the meeting of BOS, Department of Statistics for your kind consideration and approval.

With Warm Regards

--
Dr. Devendra Kumar
Head/TIC
Department of Statistics
Central University of Haryana.

5 attachments

Minutes_of_BOS_Meeting_May 10, 2022.doc
100K

3_PhD Statistics syllabus wef 2022-2023.pdf
498K

1_M.Sc. Statistics NEP Syllabus.pdf
1449K

2_M.Sc Data Science NEP.pdf
1252K

Honorarium Sitting fee (withour TA) Claim Form.pdf
116K

K Chikara Anil <akumarchi72@gmail.com> 11 May 2022 at 15:51
To: HOD Statistics <hodstatistics@cuh.ac.in>
Cc: sarora131@gmail.com

Approved.
Best Wishes,
Anil Kumar
Dr. Anil K. Chikara
Principal Scientist & Head, Division of Design of Experiments
ICAR-Indian Agricultural Statistics Research Institute
Library Avenue, New Delhi-110012
Phone (W): +91-11-25847284
(R): +91-11-45087622
(M): 09868891600 , 08851904246
Email: Anil.kumar@icar.gov.in
akumarchi72@gmail.com

[Quoted text hidden]

Sangeeta Arora <sarora131@gmail.com> 11 May 2022 at 17:31
To: HOD Statistics <hodstatistics@cuh.ac.in>
Cc: K Chikara Anil <akumarchi72@gmail.com>

Dear sir,

The minutes are approved from my side.
However , regarding the Msc. Statistics syllabus ,it is my suggestion that a paper on Non-parametric Inference may be included as a compulsory paper in the future curriculum . This may be discussed in the next Board meeting.
Rest is fine .
Thanks and regards.

Dr. Sangeeta Chopra
Professor
Department of Statistics
Panjab University
Chandigarh-160014
India
+91-9876366604

On Tue, May 10, 2022 at 5:59 PM HOD Statistics <hodstatistics@cuh.ac.in> wrote:
[Quoted text hidden]

--
Dr. Sangeeta Arora
Professor
Department of Statistics
Panjab University
Chandigarh-160014
India
+91-9876366604

Dean School Of Basic Sciences <deansobs@cuh.ac.in>

School Board Meeting on 12-09-2022 at 10:30 A.M. onwards

Dean School Of Basic Sciences <deansobs@cuh.ac.in> Wed, Sep 14, 2022 at 12:34 PM
To: "आचार्य पवन कुमार शर्मा Prof. Pawan K. Sharma" <talk2pawan@gmail.com>
Cc: bonnie_kahlon@yahoo.com, ckjaggi@gmail.com, sukhdeepsingh.cse@dcrustm.org, amitach1@yahoo.com, Amita Chandra <achandra@physics.du.ac.in>, HoD Maths <hodmaths@cuh.ac.in>, HOD Physics <hodphysics@cuh.ac.in>, HOD Statistics <hodstatistics@cuh.ac.in>, CS and IT <hodcomputerscience@cuh.ac.in>, Geography Department <hodgeography@cuh.ac.in>, "HoD, Chemistry" <hodchemistry@cuh.ac.in>, ssunita@cuh.ac.in, "Dr. Suneel Kumar" <suneelkumar@cuh.ac.in>, "Dr. Harish Kumar" <harishkumar@cuh.ac.in>, Rajeshgupta@cuh.ac.in, "Dr. Manoj Gupta" <mkgupta@cuh.ac.in>, keshav@cuh.ac.in, Suraj Arya <surajarya@cuh.ac.in>, jitendra@cuh.ac.in, "Dr. Manish Kumar" <manish.ks@cuh.ac.in>, arunkajla@cuh.ac.in, "Dr. Rakesh Kumar" <rks@cuh.ac.in>, "Dr. Kapil Kumar" <kapilstats@cuh.ac.in>, kahlon_s@pu.ac.in, "Dr. Vinod Kumar" <vinodkumar@cuh.ac.in>, akyadav@cuh.ac.in, "Dr. Devendra Kumar" <devendrastats@cuh.ac.in>, drjitendra@cuh.ac.in

Respected Madam/Sir,
Please find herewith the revised minutes (with minor modification in resolution for agenda no 3a and 3b) of the meeting of the School Board held on 12-09-2022 for your kind consideration and approval.
With Warm Regards

(Revised) Minutes of Meeting of the School Board of School of Basic Sciences held on 12.09.2022

A meeting of the **School Board of School of Basic Sciences**, Central University of Haryana, Mahendergarh was held on **12.09.2022** at **10:30 A.M.** onwards via offline and online (https://meet.google.com/rvh-ukja-fwm) mode in the office of the Dean, School of Basic Sciences, Central University of Haryana.

The following members were present in the meeting:

1. **Dr. Vinod Kumar** (Chairman)
   Dean, School of Basic Science
   Head, Department of Chemistry
   Central University of Haryana, Mahendergarh
2. **Dr. Keshav Singh Rawat** (Member)
   Head, Department of Computer Science and IT
   Central University of Haryana, Mahendergarh
3. **Dr. Jitendra Kumar** (Member)
   Head, Department of Geography
   Central University of Haryana, Mahendergarh
4. **Dr. Rajesh Kumar Gupta** (Member)
   Head, Department of Mathematics
   Central University of Haryana, Mahendergarh
5. **Dr. Suneel Kumar** (Member)
   Head, Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
6. **Prof. Harish Kumar** (Member)
   Department of Chemistry
   Central University of Haryana, Mahendergarh
7. **Prof. Sunita Shrivastava** (Member)
   Department of Physics & Astrophysics
   Central University of Haryana, Mahendergarh
8. **Dr. Manoj Kumar Gupta** (Member)

	Department of Chemistry Central University of Haryana, Mahendergarh	
9.	**Dr. Suraj Arya** Department of CS & IT Central University of Haryana, Mahendergarh	(Member)
10.	**Dr. Manish Kumar** Department of Geography Central University of Haryana, Mahendergarh	(Member)
11.	**Dr. Arun Kajla** Department of Mathematics Central University of Haryana, Mahendergarh	(Member)
12.	**Prof. Pawan Kumar Sharma** Professor, Department of Chemistry Kurukshetra University, Kurukshetra, Haryana	(External Subject Expert)
13.	**Prof. Chandra K. Jaggi** Professor, Department of Operational Research Faculty of Mathematical Sciences, DU, Delhi	(External Subject Expert)
14.	**Prof. Sukhdeep Singh** Professor, Department of Computer Science & Engg. DCRUST, Murthal, Sonipat	(External Subject Expert)
15.	**Prof. Amita Chandra** Professor, Department of Physics & Astrophysics North Campus, DU, Delhi	(External Subject Expert) Joined online
16.	**Prof. Simrit Kahlon** Professor, Department of Geography Panjab University, Chandigarh	(External Subject Expert)
17.	**Prof. Anil Kumar Yadav** Department of Mathematics Central University of Haryana, Mahendergarh	(Special Invitee)
18.	**Dr. Jitendra Kumar** Department of Mathematics Central University of Haryana, Mahendergarh	(Special Invitee)
19.	**Dr. Devendra Kumar** TIC, Department of Statistics Central University of Haryana, Mahendergarh	(Special Invitee)

At the outset, the Chairman welcomed all the members. The Chairman briefed all members about the past activities and agenda items to be discussed in the meeting.

In the meeting, the following agenda items were deliberated in detail and resolved:

Item No	Description and Recommendation	Annexure
1	Confirmation of the minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022.	
	The minutes of the meeting of the School Board of School of Basic Sciences held on 14-05-2022 were confirmed.	**Annexure-1-SOBS**
2	To consider and approve the minutes of the meeting of the Board of	

	Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Chemistry, School of Basic Sciences held on 06-09-2022, be approved.	**Annexure-A**
2a	To consider and approve the Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that a revised and updated Scheme and Syllabi of M.Sc. (Chemistry), two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-CH**
2b	To consider and approve the Scheme for first three years and Syllabi for second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in the BOS meeting of Department of Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The board noted that the scheme and syllabi for the Integrated B.Sc.-M.Sc. programme was introduced for the first time in the academic session 2021-2022. Based on the feedback from the stakeholders, the scheme is being modified to a minor extent for the purpose of giving a wider choice to the students for opting GE/AECC course which is also in line with the UGC-LOCF 2020. **It was also found that students wanted a wider choice of GE/AECC courses in I-IV semesters which was slightly deviating from the approved scheme. Considering the interest of the students supreme in line with NEP-2020, the students were practically allowed to opt for different GE/AECC courses. Therefore, the same should reflect in the scheme for the students enrolled in the session 2021-2026. Accordingly, the scheme for semesters I-IV is modified with courses categorized and should replace any previously approved scheme.** **Resolved that the Scheme for first three years (with minor modifications in first and second year) and Syllabi for the second year of Integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme for the batch 2021-2026 as approved in BOS meeting of Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-II-CH**
2c	To consider and approve the Scheme and Syllabi for first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of	

	Chemistry held on 06-09-2022 and to recommend the same to the Academic Council for consideration and approval.	
	In the light of UGC-LOCF curriculum framework 2020 coupled with the fact that the students at CUH should not be at disadvantage compared to the curriculum being adopted at the national stage, the scheme and syllabi of the Integrated B.Sc.-M.Sc. programme have been designed. **Resolved that the Scheme and Syllabi for the first three years of integrated B.Sc.-M.Sc. (Chemistry), a five-year Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Chemistry held on 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.**	**Annexure-III-CH**
3.	To consider and approve the minutes of the meetings of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of the Department of Computer Science & Information Technology, School of Basic Sciences held on 31-08-2022, be approved.	**Annexure-B**
3a	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and suggested the improvement in the course title of Programming for Data Science as "Programming for Data Science using python" in the Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023). **Further, the board suggested that the Department of Computer Science and Department of Statistics should sit together and should try to come up with a Collaborative model for the M.Sc. Data Science programme. In view of that the board resolved that the first semester Scheme and Syllabi of M.Sc. Data Science, two-year PG Programme (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology, held on 31-08-2022, with minor changes as mentioned above be approved and recommended the same to the Academic Council for consideration and approval.**	**Annexure-I-CS**
3b	To consider and approve the Scheme and Syllabi of the Diploma in	

	Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Discussed in detail and the board noted that the proposed one year Diploma Programme is of UG level and of 40 credits. However, the existing CUH ordinance allows the Diploma at PG level only with 52 credits(+-4). In view of that the board suggested that the Diploma in Computer Hardware & Networking (one-year diploma) (w.e.f. Academic Session 2022-2023) as approved in the BOS meeting of the Department of Computer Science & Information Technology held on 31-08-2022, may be offered after the amendments in the university ordinance regarding guidelines of credits for the UG degree level diploma with updated syllabi.	**Annexure-II-CS**
4.	To consider and approve the minutes of the meeting of the Board of Studies of the Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022.	
	Resolved that the minutes of the meeting of Board of Studies of Department of Physics and Astrophysics, School of Basic Sciences held on 08-08-2022, be approved	**Annexure-C**
4a	To consider and approve the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the scheme and syllabi of M.Sc. (Physics), two-year programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval after the incorporation of suggested corrections given below: **i) The name of the course "Solar Energy and Physics of Voltaic" is to be changed as "Fundamentals of Solar Energy".** **ii) In case of "Dissertation" offered to students in Semester IV, it should be explicitly mentioned that a continuous monitoring is required to be done. For that purpose, a minimum of two presentations are to be presented by students during the semester.** **iii) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of M.Sc. (Physics) 2021-23 batch.**	**Annexure-I-PH**
4b	To consider and approve the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session	

	2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Discussed in detail the Schemes and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme w.e.f. Academic Session 2022-2023 (Annexure-IIB-PH)and for 2021-26 batch (Annexure-IIA-PH). **Resolved that the Scheme and Syllabi of integrated B.Sc.-M.Sc. (Physics), a five-year Programme (w.e.f. Academic Session 2022-2023) and for 2021-26 batch as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to implementation of below-mentioned changes:** **i) The number of practical lectures for DSE, mentioned in the schemes of Semester V and Semester VI should be four instead of two.** **ii) In case of "Dissertation" offered to students in Semester X, it should be explicitly mentioned that a continuous monitoring is required. For that purpose, a minimum of two presentations by each student are required during the semester.** **iii) A course related to "Soft Skills" may be added in the list of Ability Enhancement courses that can be offered by Department of Psychology, or Department of Education or Department of English Studies** **iv) The statement "This scheme supersedes the earlier available schemes before this date" should be added in the Syllabi of Integrated B.Sc. M.Sc (Physics) for 2021-26 batch.**	**Annexure-IIA-PH** **Annexure-IIB-PH**
4c	To consider and approve the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022 and to recommend the same to Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of PhD (Physics), Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Physics and Astrophysics held on 08-08-2022, be approved and recommended the same to Academic Council for consideration and approval with subject to incorporation of below-mentioned changes: **i) The number of DCEC courses for the PhD (Physics) course work should be three. Therefore, it was decided unanimously to remove the course of "Nanotechnology and Ion Beam".**	**Annexure-III-PH**

5.	To consider and approve the minutes of the meeting of Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022	**Annexure-D1, D2, D3**
	Resolved that the minutes of the meeting of the Board of Studies of Department of Mathematics, School of Basic Sciences held on 16-3-2022, 10-05-2022 and 06-09-2022 be approved.	
5a	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2021-26 (3-6 Semesters) as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-MT**
5b	To consider and approve the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics for batch 2022-27 (1-6 Semesters) as approved in BOS meeting of Department of Mathematics held 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	**Annexure-II-MT**
	Resolved that the Scheme and Syllabi of 5-years integrated B.Sc.-M.Sc. Mathematics w.e.f Academic Session 2022-23, as approved in BOS meeting of Department of Mathematics held on 10-05-2022 and 06-09-2022, be approved, and recommended the same to Academic Council for consideration and approval.	
5c	Recommendation on the application dated 07-01-2022 received from Mr. Manish Kumar (Roll no. 191217), Research Scholar, on the recommendation of DRC (**Annexure–III-MT**), Department of Mathematics dated 13-01-2022 and BoS (16-03-2022, **Annexure-D1**).	**Annexure-III-MT**
	The case of Mr. Manish Kumar (Roll no. 191217), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 09-08-2019 and the topic of his research was approved on 19-11-2020 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Manish Kumar (Roll no. 191217), Research Scholar is required to complete a minimum residency period of two years after his topic approval date as per clause no 7.10 and 9f of Ordinance-II(A) 2019 for Ph.D. It is further resolved that the remaining**	

	residency period of 10 months 13 days should be completed in one go by Mr. Manish Kumar as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.	
6.	To consider and approve the minutes of the meeting of the Board of Studies (BOS) of the Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that the minutes of the meeting of the Board of Studies (BOS) of Department of Statistics, School of Basic Sciences held on 10-05-2022 be approved.	**Annexure-E**
6a	To get approval for changing the instructions/notes in the course for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022.	
	Resolved that changing the instructions/notes in the courses for setting the question papers as approved in minutes of the meeting of BOS of Department of Statistics, School of Basic Sciences held on 10-05-2022, be approved and recommended the same to the Academic Council for consideration and approval.	**Annexure-E**
6b	To consider and approve the Scheme and Syllabi of M.Sc. Data Science, two year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics, held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	The agenda item 6b is withdrawn as the similar programme i.e. M.Sc. Data Science has been offered by the Department of Computer Science & Information Technology under the same School. **After detailed discussion, the board suggested that the Department of Statistics and Department of Computer Science & Information Technology may start some collaborative and common programmes in near future as per the availability of the faculty members and resources.**	**Annexure-I-ST**
6c	To consider and approve the Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics held on 10-05-2022 and to recommend the same to the Academic Council for consideration and approval.	
	Resolved that the revised and updated Scheme and Syllabi of Ph.D. (Statistics) course work (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Statistics	**Annexure-II-ST**

	held on 10-05-2022, be approved and recommended the same to Academic Council for consideration and approval.	
7.	To consider and approve the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3).	
	Resolved that the Minutes of the Board of Studies (BoS) of the Department of Geography held on 11-05-2022 (Annexure-F1), 23-07-2022 (Annexure-F2) and 24-08-2022 (Annexure-F3) be approved.	**Annexure-F1, F2, F3**
7a	To consider and approve the syllabus of M.Sc. Geoinformatics programme in the Department of Geography.	
	Resolved that Scheme and Syllabi of M.Sc. Geoinformatics, two-year Programme (w.e.f. Academic Session 2022-2023) as approved in BOS meeting of Department of Geography held on 24-08-2022, be approved and recommended the same to Academic Council for consideration and approval.	**Annexure-I-Geog**
7b	To consider the request of Mr. Sourabh Yadav to continue his Ph.D. program after joining a regular job as recommended by Departmental Research Committee (DRC) held on 20-04-2022 and Board of Studies (BoS) meeting held on 11-05-2022 and to recommend the case for Academic Council.	
	The case of Mr. Sourabh Yadav (Roll no. 200785), Research Scholar was discussed in detail. He got admission in Ph.D. programme on 29-11-2020 and the topic of his research was approved on 26-10-2021 in a meeting of Board of Studies. **After detailed discussion it is resolved that Mr. Sourabh Yadav (Roll no. 200785), Research Scholar is required to complete a minimum period of two years after his topic approval date as per clause no 9e and 9f of Ordinance-II(A) for Ph.D 2020. It is further resolved that the remaining period of 1 year 10 months 27 days should be completed in one go by Mr. Sourabh Yadav as per relevant ordinance. This resolution is considered as a special case and will not be treated as a precedence. The board recommends the same to the academic council for further consideration and approval.**	**Annexure-II-Geog**
8.	Any other item(s) with the permission of the Chair.	
	No item was discussed	

The meeting ended with thanks to the Chair.

Annexure-III

CENTRAL UNIVERSITY OF HARYANA

(Established under the Central Universities Act, 2009)

(NAAC Accredited 'A' Grade)

CBCS, LOCF and NEP-2020 Based

Curriculum and Syllabi

Of

M.Sc. Statistics

(w.e.f. 2021-2022)

DEPARTMENT OF STATISTICS
SCHOOL OF BASIC SCIENCES

	BOS	School Board	Academic Council
Approved by :			
Approval Status :	x or √	x or √	x or √
Approval Date :	10-05-2022	14-05-2022	?

Table of Contents

Manoj Kumar

Vision and Mission

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

Manoj Kumar

1. Background

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

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The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About the Statistics

Recent archaeological discovery of two ancient cities of Dravidian civilization (i.e. Mohenzo Daro, Harappa), in the Indus valley revealed that about 6000 BC a people of advanced culture were settled in the region. Among other things a set of dice was found indicating their knowledge of gambling or chance. The kings and rulers even in ancient India required certain facts and figures in order to run the country and accordingly they collected information which is now known as statistical information.

According to 'Arthasastra' written by the great Indian economist 'Kautilya' (see Shamasastry 1929, Edwards 1961) a civil service existed and there were departments for accounts, revenue, mines, taxation, agriculture, and trade, etc. There was State owned gambling places which used to take five per cent of the winnings in return for a guarantee that there were no loaded dice. This indicates that some development of the probability theory existed during this period.

In 1860, India faced severe famine and the government had to take stringent steps to save the people from starvation, but the government's problem was the lack of information regarding the exact number of people living in the country and the amount of food required. In order to rectify the situation, the government introduced decennial census in 1872 but subsequently established an ad-hoc census organisation in 1881.

In 1868 as a part of statistical development in India, an annual volume of Statistical Abstract of British India was published for the first time. This annual volume which was published regularly from London was finally transferred to India in 1923. In 1883, the most important development of the statistical set-up in the country took place when, in Calcutta, the All-India Statistical Conference was held, passing numerous resolutions for the future development of statistics in the country.

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iii) About the Programme (Nature, extent and aims)

iv) Qualification Descriptors (possible career pathways)

On successful completion of the M.Sc. Statistics Programme, students of the Department are expected to work at different platforms in addition to live productive and meaningful lives. Some of the possible career paths for the postgraduate students may be:

- Indian Statistical Services
- Rcserve Bank of India Research Officer
- Statistical Officer in Different Government Agency
- Statistical Quality Control Officer in Industry
- Business analyst in Corporate Sector
- Data Analyst in Corporate Sector

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2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a group and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

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3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	Will have a strong foundation in theoretical concepts of Statistics.
PSO-2	Will be able to apply practical concepts of Statistics for solving real life problems.
PSO-3	Will be able to get comprehensive knowledge and understanding of basic concepts in statistics and its linkages with humanities, social sciences and life sciences.
PSO-4	Will have basic and advance knowledge of computational statistical techniques as required for employment in government sector and corporate world.
PSO-5	Will identify interdisciplinary applications of Statistics for enhancing career prospects in different fields and research areas.
PSO-6	Will be able to transform the existing statistical knowledge effectively for the development of new statistical ideas and concepts.
PSO-7	Will be able to analyze, interpret and present the data and bring out the meaning, correlations and interrelationships.
PSO-8	Will be able to use scientific approaches to develop the domain of human knowledge through the use of empirical data expressed in quantitative form.

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4. Postgraduate Attributes

On completion of the post graduate programme in statistics, students are expected to equip with the skills of creative, critical and rational thinking associated with statistics and its use for human society. The following attributes are expected from the students of M.Sc. Statistics:

No.	P.G. Attributes
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills
PGA-8	Life Skills
PGA-9	Life-long Learning
PGA-10	Global Competency

5. Structure of Masters Course

Types of Courses	Nature	Total Credits	%
Core Courses (CC)	Compulsory	72	75
Elective Courses (EC)	Discipline Centric Elective Courses	16	16.7
	Generic Elective Courses	8	8.3
Skilled-based courses/ Self-study based courses	Skill Enhancement Courses	4	Nil

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6. Learning Outcome Index
(Mapping of Courses with POs and PSOs)

6.1 A Mapping of Courses with POs (first year)

Semester	POs ⇨ / Course No. ⇩	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
I	CC-1	✓	✓	✓	✓		✓		✓		✓	✓
	CC-2	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-3	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-4	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-5	✓		✓	✓			✓	✓		✓	✓
	GEC-1	✓		✓	✓		✓	✓	✓		✓	✓
	GEC-2	✓		✓	✓		✓	✓	✓		✓	✓
II	CC-6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-7	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-8	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	GEC-3	✓		✓	✓		✓	✓	✓	✓	✓	✓
	GEC-4	✓		✓	✓		✓	✓	✓	✓	✓	✓

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6.1B Mapping of Courses with POs (second year)

Semester	POs ⇨ / Course No. ⇩	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
III	CC-10	✓	✓	✓	✓	✓		✓		✓	✓	✓
	CC-11	✓	✓	✓	✓	✓	✓		✓	✓		✓
	CC-12	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	CC-13	✓	✓	✓			✓	✓	✓	✓	✓	
	CC-14	✓		✓	✓	✓	✓		✓	✓	✓	✓
	DCEC-3	✓	✓	✓	✓	✓		✓	✓		✓	✓
	DCEC-4	✓	✓	✓		✓	✓	✓	✓		✓	✓
IV	CC-15	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	DCEC-5	✓	✓	✓	✓	✓		✓		✓	✓	
	DCEC-6	✓	✓	✓	✓	✓	✓		✓	✓		✓
	DCEC-7	✓	✓	✓	✓		✓	✓	✓	✓		✓
	DCEC-8	✓	✓	✓	✓	✓		✓	✓		✓	✓

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6.2A Mapping of Courses with PSOs (first year)

Semester	PSOs ⇨ / Course No. ⇩	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
I	CC-1	✓	✓		✓	✓	✓		✓
	CC-2	✓	✓	✓	✓	✓	✓	✓	✓
	CC-3	✓	✓	✓	✓	✓	✓	✓	✓
	CC-4	✓	✓	✓	✓	✓	✓	✓	✓
	CC-5		✓	✓	✓	✓	✓	✓	✓
	GEC-1	✓	✓	✓		✓	✓	✓	✓
	GEC-2	✓	✓	✓		✓	✓	✓	✓
II	CC-6	✓	✓	✓	✓	✓	✓	✓	✓
	CC-7	✓	✓	✓	✓	✓	✓	✓	✓
	CC-8	✓	✓	✓	✓	✓	✓	✓	✓
	CC-9		✓	✓	✓	✓	✓	✓	✓
	DCEC-1	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-2	✓	✓	✓	✓	✓	✓		✓
	GEC-3	✓	✓	✓		✓	✓	✓	✓
	GEC-4	✓	✓	✓		✓	✓	✓	✓

6.2B Mapping of Courses with PSOs (second year)

Semester	PSOs ⇨ / Course No. ⇩	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
III	CC-10	✓	✓	✓	✓	✓	✓	✓	✓
	CC-11	✓	✓	✓	✓	✓	✓	✓	✓
	CC-12	✓	✓	✓	✓	✓	✓	✓	✓
	CC-13	✓	✓	✓	✓	✓	✓	✓	✓
	CC-14		✓	✓		✓	✓	✓	✓
	DCEC-3	✓	✓	✓	✓		✓	✓	✓
	DCEC-4	✓	✓		✓	✓	✓	✓	✓
IV	CC-15	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-5	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-6	✓	✓	✓	✓	✓		✓	✓
	DCEC-7	✓	✓	✓	✓	✓	✓	✓	
	DCEC-8	✓	✓	✓	✓	✓	✓		✓

7. Semester-wise Courses and Credit Distribution

SEMESTER-I (24-Credits)							
Sr. No.	Course Code and Course No	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses (compulsory)							
CC-1	SBS ST 01 101 C 3104	Analysis and Linear Algebra	3	1	0	4	4
CC-2	SBS ST 01 102 C 3104	Probability Theory	3	1	0	4	4
CC-3	SBS ST 01 103 C 3104	Distribution Theory	3	1	0	4	4
CC-4	SBS ST 01 104 C 3104	Sampling Techniques	3	1	0	4	4
CC-5	SBS ST 01 105 C 0044	Practical	0	0	4	8	4
Generic Elective Courses (for students of other Departments****)							
GEC-1	SBS ST 01 101 GE 3104	Introductory Statistics	3	1	0	4	4
GEC-2	SBS ST 01 102 GE 3104	Operations Research	3	1	0	4	4
SEMESTER-II (24-Credits)							
Sr. No.	Course Code and Course No	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses (compulsory)							
CC-6	SBS ST 01 201 C 3104	Statistical Inference - I	3	1	0	4	4
CC-7	SBS ST 01 202 C 3104	Regression Analysis	3	1	0	4	4
CC-8	SBS ST 01 203 C 3104	Design of Experiments	3	1	0	4	4
CC-9	SBS ST 01 204 C 0044	Practical	0	0	4	8	4
Discipline Specific Elective Courses (any two depending on interest in specialization)							
DCEC-1	SBS ST 01 201 DCE 3104	Time Series and Statistical Quality Control	3	1	0	4	4
DCEC-2	SBS ST 01 202 DCE 3104	Operations Research	3	1	0	4	4
Generic Elective Courses (for students of other Departments****)							
GEC-3	SBS ST 01 201 GE 3104	Applied Statistics	3	1	0	4	4

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GEC-4	SBS ST 01 202 GE 3104	Biostatistics	3	1	0	4	4
SEMESTER-III (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-10	SBS ST 01 301 C 3104	Multivariate Analysis	3	1	0	4	4
CC-11	SBS ST 01 302 C 3104	Statistical Inference - II	3	1	0	4	4
CC-12	SBS ST 01 303 C 3104	Econometrics	3	1	0	4	4
CC-13	SBS ST 01 304 C 4004	Seminar	4	0	0	4	4
CC-14	SBS ST 01 305 C 0044	Practical	0	0	4	8	4
Discipline Specific Elective Courses (any two depending on interest in specialization)							
DCEC-3	SBS ST 01 301 DCE 3104	Stochastic Processes	3	1	0	4	4
DCEC-4	SBS ST 01 302 DCE 3104	Demography and Vital Statistics	3	1	0	4	4
SEMESTER-IV (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-15	SBS ST 01 401 PROJ 00016	Minor Project/Dissertation	-	-	-	-	16
Discipline Centric Elective Courses (any two depending on interest in specialization)							
DCEC-5	SBS ST 01 401 DCE 3104	Order Statistics	3	1	0	4	4
DCEC-6	SBS ST 01 402 DCE 3104	Survival Analysis	3	1	0	4	4
DCEC-7	SBS ST 01 403 DCE 3104	Decision Theory and Sequential Analysis	3	1	0	4	4
DCEC-8	SBS ST 01 404 DCE 3104	Statistical Computing	3	1	0	4	4
OR							
CC-15	SBS ST 01 401 PROJ 00024	Major Project/Dissertation	-	-	-	-	24

8. Course-Level Learning Outcomes

Course Structure

Course No: CC1	Course Name: Analysis and Linear Algebra	Course Code: SBS ST 01 101 C 3104

Batch:	Programme:	Semester:	L	T	P	Credits	Contact Hrs per Week: 4
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hours **Pre-requisite of course:** Nill

Course Objective	This course provides help to understand the mathematical concept of convergence and its mathematical formalisms. Students will be able to use some fundamental theorems of real and complex analysis and their properties.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the convergence of sequence and series of real valued functions. **CO2:** Study the complex regions and contour integrals. **CO3:** Understand of rank of matrix, characteristic roots & vectors and portioning of matrices. **CO4:** Understand the concepts of vector space and subspaces.

COURSE SYLLABUS

NOTE: Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Recap of elements of set theory, introduction to real numbers, open and closed intervals (rectangles), compact sets, Bolzano-Weirstrass theorem. Sequences and series, their convergence, real valued functions, continuous functions.	15
II	Uniform continuity, Uniform convergence. Maxima-minima of functions. Complex numbers, analytic function, Cauchy fundamental theorem, Cauchy integral theorem, contour integrations.	15
III	Determinant and trace, rank, ranks of product of two matrices, elementary matrices and Echelon forms. Partitioned matrices: addition, multiplication and inverse. Cayley Hamilton Theorem, diagonalization, generalized inverse: Definition and its computation.	15

IV	Definite and semi definite quadratic forms, index and signatures, simultaneous diagonalization of symmetric matrices (equivalent quadratic forms). Vector spaces, sub-spaces, linearly dependence and independence, orthogonalization process, orthonormal basis.	15

Suggested Readings:

1. Bartle, R.G. & Sherbert, D.R. (2011). Introduction to Real Analysis, 4th Edition. Wiley.
2. Saff, E.B. & Snider, A.D. (2014). Fundamentals of Complex Analysis with Applications to Engineering, Science and Mathematics, 3rd Edition. Pearson.
3. Rudin, W. (2013). Principles of Mathematical Analysis, 3rd Edition. McGraw Hill.
4. Biswas, S. (2012). A Textbook of Matrix Algebra, 3rd Edition. PHI Learning.

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<table>
<tr><td>Course No:
CC-2</td><td colspan="4">Course Name:
Probability Theory</td><td colspan="4">Course Code:
SBS ST 01 102 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course will lay the foundation of probability theory and statistical modelling of outcomes of real-life random experiments through various statistical distributions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand the concepts of random variables, sigma-fields generated by random variables.
CO2: Learn probability distributions and independence of random variables related to measurable functions.
CO3: Gain the ability to understand the concepts of different types of generating function, sequence of random variables, convergence, modes of convergence.
CO4: Learn the concepts of weak, strong laws of large numbers and central limit theorem.</td></tr>
</table>

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure. Random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compound probability. Boole's inequality. Conditional probability, independence of events. Bayes Theorem.	15
II	Random variable, probability mass function, probability density function, cumulative distribution function. Expectation of a random variable, properties of expectation, conditional expectation and its properties. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions.	15

III	Moment generating function, probability generating function, cumulant generating function, characteristic function and their properties. Inversion, continuity and uniqueness theorems.	15
IV	Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems.	15

Suggested Readings:

1. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
2. Rao, B.L.S.P. (2010): A First Course in Probability and Statistics. World Scientific.
3. Hogg, R.V., McKean, J. & Craig, A.T. (2013). Introduction to Mathematical Statistics, 7th Edition. Pearson.
4. Mukhopadhyay, P. (2015). Mathematical Statistics. New Central Book Agency.

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<table>
<tr><td colspan="1">Course No:
CC-3</td><td colspan="4">Course Name: Distribution Theory</td><td colspan="3">Course Code:
SBS ST 01 103 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Statistics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Formulate the mathematical and statistical models for real data sets arising in various fields in order to analyze in respect of various useful characteristics of the populations.
CO2: Understand how to use univariate distributions in real life problems.
CO3: Understand central and Non-central χ^2, t and F distributions.
CO4: Work with bivariate normal and multivariate normal distribution, which is a challenging problem in today's life.</td></tr>
<tr><td colspan="8" align="center">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
I	Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Multinomial, Hypergeometric and discrete uniform distributions; their means, variances, modes, moment generating functions, cumulant generating function, probability generating functions and characteristic functions, important properties with their proofs related to these distributions.	15
II	Continuous uniform, Exponential, Gamma, Normal, Beta, Cauchy, Laplace, Weibull, Pareto and lognormal with their properties including proofs; their means, variances, moment generating functions, cumulant generating function and characteristic functions.	15

III	Compound, truncated and mixture distributions. Central and Non-central Chi-square (χ^2), t and F distributions with their properties including their means, variances, moment generating functions, cumulant generating function and characteristic functions.. Multidimensional random variables, its pdf/pmf and cdf.	15
IV	Bivariate normal distribution with its applications and important properties including their means, variances, moment generating functions, Multivariate normal distribution, its marginal and conditional distributions and related properties.	15

Suggested Readings:

1. Krishnamoorthy, K. (2015). Handbook of Statistical Distributions with Applications, 2nd Edition, CRC Press.
2. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I. World Press.
4. Forbes, C., Evans, M., Hastings, N. & Peacock, B. (2010). Statistical Distributions, 4th Edition. Wiley.

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<table>
<tr><td>Course No:
CC-4</td><td colspan="4">Course Name: Sampling Techniques</td><td colspan="4">Course Code: SBS ST 01 104 C 3104</td></tr>
<tr><td>Batch:
2021-2023</td><td>Programme:
M.Sc. Statistics</td><td>Semester:
I</td><td>L
3</td><td>T
1</td><td>P
0</td><td>Credits
4</td><td>Contact Hrs per Week: 4
Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours
Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Learn the basic concepts of population and sample or the basic concepts of survey.
CO2: Learn the principles of sample survey and the steps involved in selecting a sample.
CO3: Understand the distinctive features of different sampling techniques and their related estimation problems.
CO4: Learn the practical applications of the various sampling techniques in real life situations.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to sampling, concept of population and sample, census and sample surveys, sampling and non-sampling errors. Types of sampling, non-probability sampling, probability sampling, basic principles of sample surveys. Simple random sampling, sampling from finite populations with and without replacement, unbiased estimation and confidence intervals for population mean and total, simple random sampling of attributes.	15
II	Stratified sampling, reasons for stratification, choice of strata, choice of sampling unit, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: merits and demerits of systematic sampling, estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling.	15
III	Ratio and regression methods of estimation, variances of the estimates,	15

	optimum property of ratio estimates, comparison among ratio, regression and simple random sampling estimates, ratio estimate in stratified sampling, comparison with the ratio and mean per unit. Cluster Sampling, estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intraclass correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.	
IV	Sampling with varying probabilities with and without replacement, sampling with probability proportional to size, Lahiri's method of selection, Horvitz-Thompson estimator, its variance and unbiased estimate of this variance. Introduction of multistage sampling, two stage sampling with equal first stage units, estimation of its mean and variance, introduction of multiphase sampling, double sampling for ratio and regression methods of estimation.	15

Suggested Readings

1. Singh, D. & Chaudhary, F.S. (2016). Theory and Analysis of Sample Survey Designs. New Age International Publishers.
2. Arnab, R. (2017). Survey Sampling Theory and Applications. Academic Press.
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. & Ashok, C. (2014). Sampling Theory of Surveys with Applications. New Delhi: Piyush Publications.
4. Cocharn, W.G. (2007). Sampling Techniques, 3rd Edition. Wiley.

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<table>
<tr><td>Course No: CC-5</td><td colspan="4">Course Name: PRACTICAL</td><td colspan="3">Course Code:
SBS ST 01 105 C 0044</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Statistics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 8</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>4</td><td>Total Hours: 120</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations. (iii) Detailed knowledge of the characterization of all the useful discrete and continuous distributions.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">CO1: Learn the basic concepts of population and sample or the basic concepts of survey.
CO2: Learn the principles of sample survey and the steps involved in selecting a sample.
CO3: Understand the distinctive features of different sampling techniques and their related estimation problems.
CO4: Learn the discrete and continuous probability distribution.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Practicals based on Distribution Theory (SBS ST 01 103 C 3104) and Sampling Techniques (SBS ST 01 104 C 3104).</td><td>120</td></tr>
</table>

Course No: GEC-1	Course Name: Introductory Statistics							Course Code: SBS ST 01 101 GE 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**		**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4		**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	The objective of this course is to define a variety of basic statistical terms and concepts, solve fundamental statistical problems, understanding of statistical fundamentals to interpret data.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the concept of measures of central tendency, dispersion, skewness and kurtosis. **CO2:** Study the fundamental concept of random variables and its probability distributions. **CO3:** Study discrete and continuous probability distributions along with their applications. **CO4:** Understand applicability of various tests of hypothesis about population parameters using sample statistic and to draw valid conclusions.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to Statistical Analysis, Measures of Central Tendency: Mean, median, mode, geometric mean, harmonic mean. Measures of Dispersion: range, mean deviation, variance, standard deviation. Quartiles. Quartile deviation, coefficient of variation, measures of skewness, measures of kurtosis.	15
II	Random experiment, outcomes, sample space, events, classical definition of probability, random variables, probability mass function, probability density function, cumulative distribution function, mathematical expectation, Variance, Binomial,	15

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	Poisson, Geometric, Exponential, Normal distributions.	
III	Null hypothesis, alternative hypothesis, type I error, type II error, level of significance, p-value and power of test. Tests for mean based on normal distribution – one sample t-test, two-sample t-test, paired-sample t-test. Tests for variance based on normal distribution – one sample and two-sample problem. One-way and Two-way analysis of variance (ANOVA) techniques.	15
IV	Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient, principle of least square, lines of regression, simple linear regression, coefficient of determination. Multiple linear regression, coefficient of multiple determination.	15

Suggested Readings:

1. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.
2. Das, N.G. (2012). Statistical Methods, Vol I & II. Tata McGraw Hill.
3. Walpole, R.E., Myers, R.H., Myers, S.L. & Ye, K.E (2012). Probability and Statistics for Engineers and Scientists. Pearson.
4. Rao, B.L.S.P. (2010): A First Course in Probability and Statistics. World Scientific.

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Course No: GEC-2	Course Name: **OPERATIONS RESEARCH**						Course Code: **SBS ST 01 102 GE 3104**
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Government/Private Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Identify and develop operational research models from the verbal description of the real system. **CO2:** Understand the characteristics of different types of decision-making environments and decision-making approaches. **CO3:** Understand the mathematical tools that are needed to solve optimization problems. **CO4:** Analyze the inventory situations.

COURSE SYLLABUS

NOTE:
1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	Origin and development of operations research (O.R.), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R. Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the LPP, generating extreme point solutions.	15
II	The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique.	15
III	Two phase method and Charnes M-method with artificial variables. The	15

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	duality problem of linear programming and its economic interpretation, transportation and assignment problems.	
IV	Game theory problem as a linear programming problem, integer programming. Replacement models and sequencing theory. Inventory management: characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time.	15

Suggested Readings

1. Taha, H.A. (2017). Operations Research: An Introduction, 10th Edition. Pearson.
2. Gass, S.I. (2010). Linear Programming, Methods and Applications, 5th Edition. Dover Books.
3. Gross, D., Shortle, J.F., Thompson, J.M. & Harris, C.M. (2017). Fundamentals of Queueing Theory, 5th Edition. Wiley.
4. Water, D. (2013). Inventory Control and Management, 2nd Edition. Wiley.

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<table>
<tr><td>Course No: CC-6</td><td colspan="2">Course Name: Statistical Inference - I</td><td colspan="6">Course Code: SBS ST 01 201 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">The objective of estimation theory is to arrive at an estimator that exhibits optimality. To provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Understand the various estimation and testing procedures to deal with real life problems.
CO2: Learn about the Fisher Information, lower bounds to variance of estimators, MVUE.
CO3: Understand the concept of Neyman-Pearson fundamental lemma, UMP test and interval estimation.
CO4: Understand the concept of critical regions, likelihood ratio test with its asymptotic distribution.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Criteria of a good estimator- unbiasedness, consistency, efficiency, sufficiency. Minimal sufficient statistic. Exponential and Pitman families of distributions. Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator. Uniformly minimum variance unbiased estimator, Complete statistic, Rao-Blackwell theorem, Lehmann-Scheffe theorem.	15
II	Method of moments, minimum chi-square estimation, maximum likelihood estimator and its properties, CAN & BAN estimators. Ancillary statistic and Basu' s theorem.	15

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	Simple and composite hypothesis, concept of critical regions, test functions, two types of error, power of the test, level of significance, Neyman-Pearson lemma, uniformly most powerful (UMP) tests.	
III	Types A, A1 critical regions, likelihood ratio test (LRT) with its asymptotic distribution, UMP tests for monotone likelihood ratio family of distributions. Similar tests with Neyman structure, Construction of similar and UMPU tests through Neyman structure.	15
IV	Confidence interval, construction of confidence intervals using pivotal, shortest expected length confidence interval, uniformly most accurate one-sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypothesis.	15

Suggested Readings:

1. Johnson, R.A. and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, Sixth Edition, Pearson Education India.
2. Hardle, W.K. and Hlavka, Z. (2015): Multivariate Statistics, Springer.
3. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley.
4. Härdle, W.K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, Springer.
5. Singh, B.M. (2004): Multivariate statistical analysis, South Asian Publishers.

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Course No: CC-7	**Course Name: Regression Analysis**				**Course Code: SBS ST 01 202 C 3104**		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	The objectives of this course are to develop theoretical foundation of regression models and understand fundamental concepts of regression analysis.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Understand simple and multiple linear regression models with their applications. **CO2:** Learn the fitting of these models to simulated and real data sets. **CO3:** Learn model adequacy using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them. **CO4:** Understand the basic concepts of logistic, Poisson and generalized linear models.

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2.	15
II	Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model. Analytical methods for selecting a transformation on study variable. Diagnostic for	15

	Leverage and Influence: Leverage, measures of influence.	
III	Generalized and weighted least square estimation. Polynomial Regression Models: Polynomial models in one variable. Orthogonal Polynomials. Piecewise polynomial (Splines). Variable Selection and Model Building: Incorrect model specifications. Evaluation of subset regression model. Computational techniques for variable selection.	15
IV	Logistic and Poisson regression models: Introduction, Linear predictor and link functions, logit, probit, odds ratio, maximum likelihood estimation, test of hypothesis. Generalized linear models: Exponential family of distribution, Linear predictors and link functions, Maximum likelihood estimation of GLM. Prediction and confidence interval with GLM.	15

Suggested Readings

1. Montegomery, D.C., Peck, E.A. & Vining, G.G. (2015). Introduction to Linear Regression Analysis, 5th Edition. Wiley.
2. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition. Wiley.
3. Draper, N.R. & Smith, H. (2011). Applied Regression Analysis, 3rd Edition. Wiley.
4. Chatterjee, S. and Hadi, A.S. (2012). Regression Analysis by Example, 5th Edition. Wiley.
5. Fox, J. and Weisberg, S. (2019). An R Companion to Applied Regression, 3rd Edition. Sage Publications.

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Course No: CC-8	Course Name: Design of Experiments							Course Code: SBS ST 01 203 C 3104
Batch:	Programme:	Semester:	L	T	P		Credits	Contact Hrs per Week: 4
2021-2023	M.Sc. Statistics	II	3	1	0		4	Total Hours: 60

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	To provide orientation of statistics while designing statistical experiments, particularly in agricultural set-up and in pharmaceutical production processes. Exposure to various statistical designs leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the concepts of design of experiments and application of ANOVA, ANCOVA. **CO2:** Construct complete and partially confounded factorial designs and perform their analysis. **CO3:** Design and analyse incomplete block designs, understand the concepts of efficiency of BIBD relative to RBD. **CO4:** Understand the concepts of first order, orthogonal and treatment-control designs.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to design of experiments. Three basic principles of design of experiments: randomisation, replication and local control. Uniformity trials. Analysis of basic design, asymptotic relative efficiency, missing plot techniques, analysis of covariance for CRD and RBD.	15
II	Factorial experiments: 2^k, 3^2 and 3^3 systems only. Complete and partial confounding, factorial replication in 2^k systems. Two-level fractional factorial designs: introduction, the one-	15

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	quarter fraction of the 2^k design. Alias structure in fractional factorials and other designs.	
III	Incomplete block design: balanced incomplete block design, simple lattice design, split-plot design, strip-plot design, comparison of two treatments, efficiency of BIBD relative to RBD.	15
IV	Response surface methodology, first order designs, and orthogonal designs, treatment-control designs, model variation and use of transformation.	15

Suggested Readings:

1. Montgomery, D.C. (2013). Design and Analysis of Experiments, 8th Edition. Wiley.
2. Toutenburg, H. & Shalabh (2010). Statistical Analysis of Designed Experiments, 3rd Edition. Springer.
3. Cobb, G.W. (2014). Introduction to Design and Analysis of Experiments. Wiley.
4. Lawson, J. (2014). Design and Analysis of Experiments with R. CRC Press.

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<table>
<tr><td>Course No:
CC-9</td><td colspan="5">Course Name: Practical 102</td><td colspan="3">Course Code: SBS ST 01 204 C 0044</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Statistics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 8</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>4</td><td colspan="2">Total Hours: 120</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">To provide orientation of statistics while designing statistical experiments, particularly in agricultural set-up and in pharmaceutical production processes. Exposure to various statistical designs leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">CO1: Understand simple and multiple linear regression models with their applications.
CO2: Understand the various estimation and testing procedures to deal with real life problems.
CO3: Understand the concepts of design of experiments and application of ANOVA, ANCOVA.
CO4: Construct complete and partially confounded factorial designs and perform their analysis.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="8">Practicals based on Statistical Inference - I (SBS ST 01 201 C 3104), Regression Analysis (SBS ST 01 202 C 3104) and Design of Experiments (SBS ST 01 203 C 3104).</td><td>120</td></tr>
</table>

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<table>
<tr><td>Course No:
DCEC-1</td><td colspan="4">Course Name:
Time Series and Statistical Quality Control</td><td colspan="3">Course Code:
SBS ST 01 201 DCE 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Statistics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to equip the students of M.Sc. Statistics with knowledge of industrial statistics as well as applications of Time series in real life.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Study the components of time series and its use to forecast the future values.
CO2: Learn auto covariance and auto-correlation functions.
CO3: Study the concept and applications of control charts for variables and attributes.
CO4: Understand different sampling inspection plans and their applications.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Time series: objects, decomposition, examples of time series, trend component, polynomial, logistic, Gompertz, log-normal trend functions, smoothing of moving average, Spencer's formulae and effects, variate difference method, Measurement of seasonal and cyclical functions, Peridogram and harmonic analysis.	15
II	Concepts of auto regression, autocorrelation, partial autocorrelation and correlogram analysis. Linear models for stationary time series. First order moving average (MA(1)) process, second order moving average (MA(2)) process. First order autoregressive process (AR(1)), second order	15

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	autoregressive process (AR(2)). Autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.	
III	Concept of quality and meaning of control, Chance and assignable causes of quality variation, product and process controls. Concept of 3-sigma limits. Modified and specifications limits. Different types of control charts like $\bar{X}$, R, np, p and c with their applications in industry.	15
IV	Sampling inspection v/s 100% inspection. Single, double, multiple and sequential sampling plans for attributes. Operating characteristic (OC), AOQL, ASN and ATI curves. Concept of producer's and consumer's risk, AQL and LTPD. Variable sampling plans.	15

Suggested Readings:

1. Montgomery, D.C., Jennings, C.L. & Kulahci, M. (2015). Introduction to Time Series Analysis and Forecasting, 2nd Edition. Wiley.
2. Brockwell, P.J. & Davis R.A. (2016). Introduction to Time Series and Forecasting, 2nd Edition. Springer.
3. Montgomery, D.C. (2012). Introduction to Statistical Quality Control, 7th Edition. Wiley.
4. Grant, E. & Leavenworth, R. (2012). Statistical Quality Control, 7th Edition. Tata McGraw Hill.

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Course No: DCEC-2	Course Name: OPERATIONS RESEARCH						Course Code: SBS ST 01 202 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4		
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**		

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Government/Private Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Identify and develop operational research models from the verbal description of the real system. **CO2:** Understand the characteristics of different types of decision-making environments and decision-making approaches. **CO3:** Understand the mathematical tools that are needed to solve optimization problems. **CO4:** Analyze the inventory and queueing models.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Origin and development of operations research (O.R.), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R. Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the LPP, generating extreme point solutions.	15
II	The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique. Two phase method and Charnes M-method with artificial variables. The duality problem of linear programming and its economic	15

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	interpretation, transportation and assignment problems.	
III	Inventory management: characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time. All unit and incremental discounts. Single period stochastic models.	15
IV	Queueing Theory: Introduction of the queuing system, Various components of a queueing system. Pure Birth Process; Pure Death Process, Birth and Death Process, M/M/1 , M/M/1 (Generalized), M/M/1/FCFS/K/∞, M/M/C, Erlang's loss model.	15

Suggested Readings

1. Taha, H.A. (2017). Operations Research: An Introduction, 10th Edition. Pearson.
2. Gass, S.I. (2010). Linear Programming, Methods and Applications, 5th Edition. Dover Books.
3. Gross, D., Shortle, J.F., Thompson, J.M. & Harris, C.M. (2017). Fundamentals of Queueing Theory, 5th Edition. Wiley.
4. Water, D. (2013). Inventory Control and Management, 2nd Edition. Wiley.

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Course No: GEC-3	Course Name: Applied Statistics						Course Code: SBS ST 01 201 GE 3104
Batch: 2021-2023	Programme: M.Sc. Statistics	Semester: II	L	T	P	Credits	Contact Hrs per Week: 4
			3	1	0	4	Total Hours: 60

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL
Course Objective	The course aims to study various models and components of time series analysis for forecasting purposes and various methods to control the quality of a product. It also gives the study of distribution of population with respect to birth, migration, aging and death.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the components of time series and their measurement. **CO2:** Study process control and its tools-control chart for variables and attributes. **CO3:** Learn the basic measures of mortality and fertility and their application. **CO4:** Understand life tables and their uses in real life problems.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, measurement of trend by method of moving averages, method of semi-averages and method of least squares (linear, quadratic and exponential). Measurement of seasonal variations by method of simple averages, method of ratio to trend.	15
II	Statistical Quality Control: Importance of statistical methods in industrial research and practice, determination of tolerance limits, causes of variations in quality: chance and assignable. General theory of control charts, process and product control, control charts for variables: X- bar and R-charts, control charts for attributes: p and c-charts.	15

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III	Demographic Methods: Introduction, measurement of population, rates and ratios of vital events, measurement of mortality: Crude Death Rate, Specific Death Rate (w. r. t. age and sex), Infant Mortality Rate, Standardized death rates.	15
IV	Life (mortality) tables: definition of its main functions and uses, measurement of fertility and reproduction: Crude Birth Rate, General Fertility Rate and Total Fertility Rate. Measurement of population growth: Gross Reproductive Rate, Net Reproductive Rate.	15

Suggested Readings:

1. Mukhopadhyay, P. (2011). Applied Statistics, 2nd Edition. Books and Allied (P.) Ltd.
2. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. II. 9th Edition. World Press.
3. Montegomery, D.C. (2013). Statistical Quality Control: A Modern Introduction, 7th Edition. Wiley.
4. Burr, J.T. (2014). Elementary Statistical Quality Control, 2nd Edition. CRC Press.

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Course No: GEC-4	Course Name: Biostatistics						Course Code: SBS ST 01 202 GE 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	The objective of this course is to define a variety of data types, representation and interpretation of data, sampling techniques and design of experiments.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** able to learn about different types of data & scales also tabulated representation of data. **CO2:** understand how to represent data graphically. **CO3:** able to learn how to collect samples and analyze them by using different sampling techniques. **CO4:** understand the concept of design of experiments and their applications.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Statistical Data, Types of Data: attributes and variables, discrete & continuous data, Primary data, Secondary data, Different types of scales- nominal, ordinal, ratio and interval. Presentation of data: Construction of tables with one or more factors of classification.	15
II	Diagrammatic and graphical representation of data: Pictorial representation, Bar chart, Pie Chart, histogram, frequency polygon, frequency curve and ogives. Stem and leaf chart. Box Plot Central tendency and its measures: Mean, Median and Mode	15
III	Concepts of population and sample, census and sample surveys, Basic concepts in sampling and designing of a large scale surveys, steps involved in sample survey, Types of sampling: sample and the	15

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	probability sample; simple random sampling with and without replacement; Stratified sampling; Systematic sampling.	
IV	Experimental designs: Terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.	15

1. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.
2. Das, N.G. (2012). Statistical Methods, Vol I & II. Tata McGraw Hill.
3. Daniel, W.W. & Cross, C.L. (2012). Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition. Wiley.
4. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

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<table>
<tr><td>Course No: CC-10</td><td colspan="3">Course Name: Multivariate Analysis</td><td colspan="4">Course Code: SBS ST 01 301 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Multivariate analysis is applicable in almost all scientific studies, for example in Anthropology, Life sciences, Agriculture and Economics, when one deals with several variables simultaneously.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Account for important theorems and concepts in multivariate analysis.
CO2: Understand the concept of Wishart and Hotelling's T^2 distribution.
CO3: Understand the link between multivariate techniques and corresponding univariate techniques.
CO4: Conduct statistical inference about multivariate means including hypothesis testing, confidence region calculation, etc.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known. Matrix normal distribution. Multivariate central limit theorem.	15
II	Wishart matrix, its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic and its	15

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	distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations. Mahalanobis' D^2.	
III	**[Course Outcome (s) No. : CO3]** Likelihood ratio test criteria for testing of independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations, equality of a covariance matrix to a given matrix, equality of a mean vector and a covariance matrix to a given vector and a given matrix.	15
IV	**[Course Outcome (s) No. : CO4]** Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations. Principal components, canonical variables and canonical correlations. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.	15

Suggested Readings:

1. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
2. Lehmann, E.L. & Casella, G. (2014). Theory of Point Estimation, 2nd Edition. Springer.
3. Lehmann, E.L. & Romano, J.P. (2010). Testing Statistical Hypotheses, 3rd Edition. Springer.
4. Casella, G. & Berger, R.L. (2013). Statistical Inference, 2nd Edition. Cengage Learning.

Manoj Kumar

<table>
<tr><td>Course No:
CC-11</td><td colspan="4">Course Name: Statistical Inference-II</td><td colspan="4">Course Code: SBS ST 01 302 C 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">The main objective of the course is to provide the detailed knowledge of the characterization of another inferential procedure that is Bayesian and non-parametric Inference.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completing this course, student is expected to learn the following:
CO1: Describe the role of the posterior distribution, the likelihood function, prior and the posterior distribution about a parameter in Bayesian framework.
CO2: Understand inferences for lifetime models in Bayesian framework.
CO3: Learn the basic concepts of nonparametric techniques.
CO4: Understand the sequential probability ratio test and its application.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Elements of the Bayesian paradigm. Introduction to prior and posterior distributions, loss functions. Bayes risks, Bayesian paradigm versus classical paradigm. Prior distribution, subjective determination of prior distribution, improper priors, non-informative priors, conjugate prior families, construction of conjugate families using sufficient statistic for fixed dimensions.	15
II	Bayesian estimation of parameters of some well-known distributions like binomial, multinomial, Poisson, normal, lognormal, exponential, Rayleigh and Weibull distributions. Credible and highest posterior density (HPD) interval, HPD credible intervals in case of normal, gamma, exponential and Weibull distributions.	15

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III	Concept of nonparametric and distribution-free methods, probability integral transformation, empirical distribution function, kernel, one-sample and two-sample *U*-Statistics, test of independence, sign test, rank-order statistics, Wilcoxon signed-Rank test. Wald-Wolfowitz runs test, Kolmogorov-Smirnov two-sample test, median test, Mann-Whitney U test.	15
IV	The sequential probability ratio test (SPRT) and its application to binomial, Poisson, geometric, exponential, normal, operating characteristic (OC) function of SPRT, average sample number (ASN) function and their application, Wald's fundamental identity and its uses.	15

Suggested Readings:

1. Berger, J.O. (2013): Statistical Decision Theory and Bayesian Analysis, Springer.
2. Hollander, M., Wolfe, D. and Chicken, E. (2013): Nonparametric Statistical Methods, 3rd Edition, Wiley.
3. Gibbons, J.D. and Chakraborti, S. (2010): Nonparametric Statistical Inference, 5th Edition, CRC Press.
4. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.

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Course No: CC-12	Course Name: Econometrics						Course Code: SBS ST 01 303 C 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** NIL
Course Objective	The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Understand the basic concepts of econometric models. **CO1:** Learn knowledge of various econometric models, estimation methods and related econometric theories. **CO1:** Understand the statistical techniques to model relationships between variables and make predictions. **CO1:** Learn how to conduct econometric analysis of data.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to econometrics. A review of least squares and maximum likelihood estimation methods of parameters in classical linear regression model and their properties. Generalized least squares estimation and prediction, construction of confidence regions and tests of hypotheses. Regression analysis under linear restrictions, restricted least squares estimation method and its properties. Autocorrelation, sources and consequences, Autoregressive process tests for autocorrelation, Durbin Watson test.	15
II	Problem of Multicollinearity, its implications. Source of multicollinearity, tools for handling the problem of multicollinearity. Remedies for multicollinearity. Ridge regression. Heteroskedasticity, consequences and tests for it, estimation procedures under heteroskedastic disturbances, Bartlett's test, Breusch Pagan test and	15

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	Goldfelf Quandt test. Dummy Variable Models.	
III	Specification Error Analysis. Tests for Structural Change and Stability, Asymptotic theory and regressors. Stein-Rule Estimation. Instrumental variable estimation. Measurement Error Models.	15
IV	Simultaneous equations model, problem of identification, necessary and sufficient condition for the identifiability of parameters in a structural equation, ordinary least squares, indirect least squares, two-stage least squares and limited information maximum likelihood method.	15

Suggested Readings

1. Gujrati, D.N. & Porter, D.C. (2017). Basic Econometrics, 6th Edition. McGraw Hill.
2. Maddala, G.S. & Lahiri, K. (2010). Introduction to Econometrics, 4th Edition. Wiley.
3. Greene, W.H. (2012). Econometric Analysis, 7th Edition. Pearson.
4. Studenmund, A.H. & Johnson, B.K. (2017). Using Econometrics: A Practical Guide, 7th Edition. Pearson.

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<table>
<tr><td>Course No: CC-13</td><td colspan="5">Course Name: Seminar</td><td colspan="3">Course Code: SBS ST 01 304 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs per Week: 4</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="7">Examination Duration: 3 Hours</td></tr>
<tr><td colspan="7">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">The purpose of this course is to give students a solid foundation in communication skill of statistical techniques</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">CO1: Understand the basic concepts of econometric models.
CO2: Understand inferences for lifetime models in Bayesian framework.
CO3: Understand the concept of multivariate normal distribution.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td colspan="2">Hours</td></tr>
<tr><td colspan="7">Each student must present at least one seminar which will be followed by discussion session with participation from other students and the concerned faculty members present. The student must also submit the slides/write-up of the presentation content to the Student Advisor (Faculty). The seminar, participation in discussions, the submitted slides and overall attendance (as per ordinance) will form the basis of the evaluation. There will be no separate final exam for this course.</td><td colspan="2">60</td></tr>
<tr><td colspan="9"></td></tr>
</table>

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Course No: CC-14	Course Name: Practical 103				Course Code: SBS ST 01 305 C 0044		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 8**
2021-2023	M.Sc. Statistics	III	0	0	4	4	**Total Hours: 120**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					
Course Objective	The purpose of this course is to give students a solid foundation in multivariate techniques, problems of estimation and analysis econometric models.						
Course Outcomes:	**CO1:** Understand the concepts of multivariate normal distribution with help of R software **CO2:** Understand the concepts analysis econometric models with help of R software **CO3:** Understand the concepts point and interval estimator estimation, with help of R software						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours
Practicals based on Multivariate Analysis (SBS ST 01 301 C 3104), Statistical Inference – II (SBS ST 01 302 C 3104) and Econometrics (SBS ST 01 302 CC 4004).		120

Course No: DCEC-3	Course Name: Stochastic Processes						Course Code: SBS ST 01 301 DCE 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL					
Course Objective	The objective of this course is to apprise the students with the basic concepts of the theory of stochastic processes in continuous time, also to make them able to use various analytical and computational techniques to study stochastic models that appears in applications.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the fundamental concept of stochastic processes and its applications. **CO2:** Understand Markov processes and Markov chains and their applications in real world. **CO3:** Study the branching process and its properties. **CO4:** Understand Poisson processes and its variations.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Stochastic Processes: Introduction, classification according to state space and time domain. Countable state Markov chains, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities and their limits, stationary distribution.	15
II	Branching Processes: Properties of generating function of branching processes, probability of ultimate extinction, distribution of the total number of progeny, generalization of the classical Galton-Watson branching process, general branching processes, random walk and gambler's ruin problem.	15
III	Continuous-time Markov Processes: Poisson process and related distributions, generalizations of Poisson process, simple birth-process, simple death-process, simple birth-death process, linear birth-death process. First passage time distribution.	15

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IV	Renewal Theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, central limit theorem for renewals, study of residual and excess lifetime's process. Renewal reward Process, Markov renewal and semi-Markov processes, Markov renewal equations.	15

Suggested Readings:

1. Medhi, J. (2012). Stochastic Processes, 3rd Edition. New Age International.
2. Ross, S.M. (2016). Stochastic Processes, 2nd Edition. Wiley India.
3. Karlin, S. & Taylor, H.M. (2012). A First Course in Stochastic Processes, 2nd Edition. Academic Press.
4. Prabhu, N.U. (2010). Stochastic Processes: Basic Theory and its Applications. World Scientific.

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<table>
<tr><td>Course No: DCEC-4</td><td colspan="3">Course Name: Demography and Vital Statistics</td><td colspan="4">Course Code: SBS ST 01 302 DCE 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to make the students conversant with various techniques used in summarization and analysis of data related to demographic and vital events.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Understand the basic concepts of demography and vital statistics.
CO2: Understand the trends of mortality and compare and contrast among different age and sex group.
CO3: Identify the components of population change, including the effects of changing birth, death and migration rates, and demonstrate their influences on age structure.
CO4: Do population projection by different methods.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data, adjustment of age data. Use of Whipple, Myer and UN indices, population composition, dependency ratio, population transition theory.	15
II	Measures of Fertility: Stochastic models for reproduction, distribution of time to first birth, inter-live birth intervals and of number of births. Estimation of parameters, estimation of parity progression ratio from open birth interval data.	15

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III	Measures of Mortality: Construction of abridged life tables, distribution of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate models for population growth and their fitting to population data. Stochastic models for population growth.	15
IV	Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility. Methods for population projection. Use of Leslie matrix. Nuptuality and its measurements.	15

Suggested Readings:

1. Kumar, R. (2006): Technical Demography, New age International (P) Ltd, New Delhi.
2. Samuel, P., Patrick, H. and Michel, G. (2000): Demography: Measuring and Modeling Population Processes, Wiley-Blackwell.
3. Rowland, D.T. (2003): Demographic Methods and Concepts, Oxford university press, Inc., New York.
4. Pathak, K. B. and Ram, F. (2013): Techniques of Demographic Analysis, Himalaya Publishing House.
5. Keyfitz, N. and Caswell, H. (2005): Applied Mathematical Demography, Springer.

Manoj Kumar

<table>
<tr><td>Course No:
CC-15</td><td colspan="2">Course Name: Minor Project/Dissertation</td><td colspan="5">Course Code: SBS ST 01 401 PROJ 00016</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: -</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>16</td><td>Total Hours: -</td></tr>
<tr><td colspan="8">Total Evaluation Marks: 400
CIE: 120 Marks
TEE: 280 Marks</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">Content</td></tr>
<tr><td colspan="8">The aim of the dissertation or project work is to familiarize the students with advanced research. The topic for the project work is to be decided by the supervisor/guide concerned. The project report/ dissertation is to be evaluated by a committee constituted by the Head of Department of Statistics having at least one external expert.</td></tr>
</table>

<table>
<tr><td>Course No:
DCEC-5</td><td colspan="2">Course Name: Order Statistics</td><td colspan="5">Course Code:
SBS ST 01 401 DCE 3104</td></tr>
<tr><td>Batch:</td><td>Programme:</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per</td></tr>
</table>

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2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Week: 4** **Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL
Course Objective	*The objective of the course is to learn general strategies for problems about order statistics and how to learn to find the median (or k^{th} largest) in linear average-case number of comparisons (and time).*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the basic concepts of order statistics, joint, marginal and conditional probabil distributions of order statistics. **CO2:** Learn about distribution-free confidence intervals for population quantile and distributio free tolerance intervals for population distributions. **CO3:** Construct the recurrence relations and identities for moments of order statistics. **CO4:** Enhanced with the concepts of distributions of order statistics for independently and n identically distributed variates and also for dependent variates.

COURSE SYLLABUS

NOTE:
1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to order statistics, joint, marginal and conditional distributions of order statistics (discrete and continuous cases). Distribution of the range and other systematic statistics, order statistics as a Markov chain. Examples based on discrete and continuous distributions.	15
II	Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of the range. Approximations to moments in terms of the quantile function and its derivatives. lemma, uniformly most powerful (UMP) tests.	15

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III	Moments of order statistics, recurrence relations and identities for moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics.	15
IV	Order statistics for independently and not identically distributed (i.ni.d.) variates, Concomitants of order statistics. Random division of an interval and its applications. Order statistics from a sample containing a single outlier. Concepts of record values and generalized order statistics.	15

Suggested Readings:

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables: Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publishers.

Course	**Course Name: Survival Analysis**	**Course Code: SBS ST 01 402 DCE**

Manoj Kumar

No: DCEC-6					3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL
Course Objective	The objective of this course is to provide the applications of statistics in handling survival data. This course introduces the concept of censoring and various life time distributions used to analyse such data.
Course Outcomes:	On completion of this course, students will be able to: • Understand basic concepts of survival data and lifetime models. • Learn how to handle censored data under different scenarios. • Learn non-parametric estimation of survival function. • Learn the Log-Rank test for testing differences between survival curves and Cox' regression model for estimating and testing effects of covariates.

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Concepts of survival function, failure rate or hazard function, mean residual life and their properties. Ageing classes- IFR, DFR, IFRA, DFRA, NBU, NBUE, BT and UBT, scaled TTT transform and characterization of ageing classes.	15
II	Life testing plans or censoring methods, right and left censoring, concepts of Type-I (time) and Type-II (failure), random censoring schemes. Life distributions-exponential, Weibull, log-logistic, gamma, log-normal distributions. Parametric inference- estimation of parameters associated with various life time distributions and life testing plans.	15
III	Nonparametric methods of estimation of survival function - actuarial estimator, Kaplan-Meier estimator. Tests of exponentiality against non-parametric classes-Total time on Test, Deshpande Test.	15
IV	Two sample problem - Gehan test, log-rank test, Mantel-Haenzel test. Cox proportional hazards model, competing risks model.	15

Suggested Readings

1. Deshpande, J.V. & Purohit, S.G. (2016). Life Time Data: Statistical Models and Methods, 2nd Edition. Word Scientific.

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2. Lee, E.T. & Wang, J.W. (2015). Statistical Methods for Survival Data Analysis, 4th Edition. Wiley.
3. Miller, R.G. (2011). Survival Analysis, 2nd Edition. Wiley.
4. Moore, D.F. (2016). Applied Survival Analysis using R. Springer.

Course No:	**Course Name:** Decision theory and sequential analysis	**Course Code: SBS ST 01 403 DCE 3104**

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DCEC-7							
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:** 4
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL

Course Objective	The main objective of this course is to provide the detailed knowledge of the decision theory and sequential analysis.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the concept of decision theory and sequential analysis. **CO2:** Learn how to perform posterior decision analysis and hypothesis testing. **CO3:** Understand the decision rule and fundamental identity in sequential analysis. **CO4:** Learn the wider applications of decision principles of Bayesian and frequentist approaches.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Elements of decision theory: Expected loss, decision rules and risks - Bayesian expected loss, frequentist risks, randomized and nonrandomized decision rules, admissible decision rule, complete, essential complete and minimal complete classes of decision rules and their relationship, minimax and Bayes decision rule, estimation testing viewed as decision rule problem, Bayes and minimax estimators. Minimax and Bayes tests in simple cases.	15
II	Decision principles: the conditional Bayes decision principle and frequentist decision principles. Misuse of classical Inference procedures, the frequentist perspective, the conditional perspective, the likelihood principle, choosing a paradigm or decision principle. Utility theory: introduction,	15

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	the utility of money.	
III	Bayesian decision theory: Posterior decision analysis, estimation, finite action problems and hypothesis testing. Minimax Analysis: Introduction, game theory, basic elements, general techniques for solving games, finite games, the minimax theorem.	15
IV	Sequential Decision rule: Stopping rule, terminal decision rule. Bayes and minimax sequential decision Rules. Invariant sequential decision problems, sequential test of a simple hypothesis. The sequential probability ratio test, the fundamental identity of sequential analysis.	15

Suggested Readings:

1. Robert, C.P. (2013): The Bayesian Choice: A Decision Theoretic Motivation, Springer.
2. Berger J.O. (2013): Statistical Decision Theory and Bayesian Analysis, Springer.
3. Wald, A. (2013): Sequential Analysis, Dover Publications.
4. Mukhopadhyay, N. and de Silva, B.M. (2008): Sequential Methods and Their Applications, CRC Press.

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<table>
<tr><td colspan="2">Course No: DCEC-8</td><td colspan="4">Course Name: Statistical Computing</td><td colspan="3">Course Code: SBS ST 01 404 DCE 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2" colspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks: 100
CIE: 30 Marks
TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 Hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: NIL</td></tr>
<tr><td>Course Objective</td><td colspan="8">The students will study the statistical simulation using Computers. It contains introduction to System, Models, Simulation, Random Number Generation and Variance Reduction Techniques.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">On completion of this course, students will be able to:
CO1: Understand the basic ideas of random number generation using different techniques.
CO2: Learn theoretical methods and practicable techniques of statistical simulations.
CO3: Understand how to apply Monte Carlo simulations and the EM algorithm.
CO4: Learn how to handle real world problems with large scale data.</td></tr>
</table>

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction and need of statistical simulation. Random number generation, requisites of a good random number, methods of random number generation such as linear congruential and mixed congruential, statistical tests for pseudo random numbers. Methods of generating random variables such as inverse transforms, composition and acceptance-rejection methods.	15
II	Monte Carlo integration and variance reduction techniques: Hit or miss Monte Carlo method, sample mean Monte Carlo method, importance sampling, correlated sampling control variates, stratified sampling, antithetic variates, partition of region.	15
III	EM algorithm: applications to missing and incomplete data problems, mixture models. Smoothing with kernels, density estimation, simple non-parametric regression. Smoothing with kernels: density estimation, choice of kernels.	15

IV	Simulation based testing: simulating test statistics and power functions, permutation tests. Bootstrap methods: resampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression. Jackknife and cross validation: Jacknife in sample surveys, cross-validation for tuning parameters.	15

Suggesting Readings

1. Rubinstein, R.Y. and Kroese, D.P. (2008): Simulation and the Monte Carlo Method, Second Edition, Wiley. ·
2. Voss, J. (2014): An Introduction to Statistical Computing: A Simulation Approach, Wiley.
3. Ross, S.M. (2012): Simulation, Fifth Edition, Academic Press.
4. Thomopoulos, N.T. (2013): Essentials of Monte Carlö Simulation, Springer.

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<table>
<tr><td>Course No: CC-15</td><td colspan="3">Course Name: Major Project/Dissertation</td><td colspan="4">Course Code: SBS ST 01 401 PROJ 00024</td></tr>
<tr><td rowspan="2">Batch:
2021-2023</td><td rowspan="2">Programme:
M.Sc. Statistics</td><td rowspan="2">Semester:
IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: -</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>24</td><td>Total Hours: -</td></tr>
<tr><td colspan="8">Total Evaluation Marks: 600
CIE: 180 Marks
TEE: 420 Marks</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">Content</td></tr>
<tr><td colspan="8">The aim of the dissertation or project work is to familiarize the students with advanced research. A departmental committee will distribute the topics according to the skill and merit of the students. The project report/dissertation will be evaluated by a committee constituted by the Head of Department of Statistics having at least one external expert.</td></tr>
</table>

9. **Teaching-Learning Process**

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

10. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face-to-face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- Student-centric pedagogical approach focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

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11. Assessment and Evaluation

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. References

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. Appendices

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Annexure – II

Annexure-XIV

DEPARTMENT OF STATISTICS

Scheme and Syllabus
Ph.D. (Statistics)
w.e.f. 2022-2023

CENTRALUNIVERSITY OF HARYANA
JANT-PALI, MAHENDERGARH

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COURSE WORK: Ph.D. PROGRAMME IN STATISTICS

Course Type

- Core Course
- Elective Course

Total Credits: 14

S. No.	Course Title	Course Code	Credits	Course Type
1.	Research Methodology	SBS ST 02 01 01 C 6006	6	Core
2.	Research and Publication Ethics	SBS ST 02 01 02 C 2002	2	Core
3.	Advanced Reliability Theory	SBS ST 02 01 01 E 6006	6	Elective
4.	Bayesian Inference	SBS ST 02 01 02 E 6006	6	Elective
5.	Order Statistics	SBS ST 02 01 03 E 6006	6	Elective
6.	Reliability and Life Testing	SBS ST 02 01 04 E 6006	6	Elective

Note: Students will be required to choose any one subjects from the elective courses.

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RESEARCH METHODOLOGY

(SPMS STAT 02 01 01 C 6006)

Course Objectives:

To familiarize the students with general techniques of performing analysis of data and modelling using various simulation techniques. This course will enable students to design experiments and methods to extract data.

Learning Outcomes:

1. To motivate students for research in different fields of Physics, Mathematics and Statistics.
2. To teach students different techniques of research modelling, data collection, designing and planning of experiments.
3. To enable to analyze data and write report based on data analyzed.

UNIT I

Research Problems: Meaning, Motivation, Objectives and types of research, Significance of research, Research proposals and aspects, Criteria of good research, Research formulation and hypotheses, Selection and necessity of defining the problem, Literature review, Primary and secondary sources, Reviews, Treatise, Monographs, Patents.

UNIT II

Research Design: Need, Problem Definition, Variables, Research design concepts, Research design process, Research Modeling: Types of models, Model building and stages, Data collection, processing and analysis, Simulation techniques using computer software(s).

UNIT III

Design and Planning of Experiments: Aims and objectives, expected outcome, methodology to be adopted, importance of reproducibility of research work, Interpolation, Extrapolation, Types of errors (rounding, truncation, machine and random), Error analysis and least square curve fitting. Analysis of Variance components (ANOVA) for fixed effect model, Objectives and basic principles of designs of experiments. Complete randomized design (CRD), Randomized block design (RBD) and Latin square design (LSD).

UNIT IV

Data mining and Report Writing: Library resources, Internet, Scientific search engines, Introduction to Latex/Google docs, Structure and component of research paper, Presenting the research paper/thesis, Journal impact factor, Citation index, References and bibliography, Copyright, Plagiarism and ethics in research, Communication and presentation.

Suggested Readings:

1. Kothari, C.R & Garg, G. (2014). Research Methodology: Methods and Techniques, 3rd Edition. New Age International Publishers, New Delhi.
2. Pannerselvan, R. (2009). Research Methodology. Prentice Hall of India, New Delhi.
3. Singh, Y.K. (2008). Fundamental of Research Methodology and Statistics. New Age International Publishers, New Delhi.
4. Montgomery, D.C. (2013). Design and Analysis of Experiments. 8th Edition. Wiley India.
5. Prathapan, K. (2014). Research Methodology for Scientific Research. IK International, New Delhi.

Research and Publication Ethics
(SBS ST 02 01 02 C 2002)

End Semester Examination: 60
Internal Assessment: 40
Total: 100

Course Objectives:

The course aimed is to aware the students about the basic ethics of research and publication. The contents will serve as basic tools to groom the students about plagiarism in research.

Learning Outcomes:

On completion of the course, the student should be able to:

- Understand the basic ethics of research.
- Maintain the research integrity and intellectual honesty.
- Understand the scientific misconduct and proper citations.
- Acquire knowledge of databases and software's.

Theory

RPE 01: Philosophy and Ethics (3 hrs.)

1. Introduction to philosophy: definition, nature and scope, concept, branches

2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

RPE 02: Scientific Conduct (5 hrs.)

1. Ethics with respect to science and research

2. Intellectual honesty and research integrity

3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)

4. Redundant publications: duplicate and overlapping publications, salami slicing

5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs.)

1. Publication ethics: definition, introduction and importance

2. Best practices / standards setting initiatives and guidance: COPE, WAME, etc.

3. Conflicts of interest

4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types 5. Violation of publication ethics, authorship and contributorship

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6. Identification of publication misconduct, complaints and appeals 7. Predatory publishers and journals

Practice RPE 04: Open Access Publishing (4 hrs.)

1. Open access publications and initiatives

2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices

3. Software tool to identify predatory publications developed by SPPU

4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE 05: Publication Misconduct (4 hrs.)

A. Group Discussion (2 hrs.)

1. Subject specific ethical issues, FFP, authorship

2. Conflicts of interest

3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

1. Use of plagiarism software like Turnitin, Urkund and other open source software tools.

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs,)

1. Indexing databases Research Metrics 2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score

2. Metrics: h index, g index, i10 index, almetrics.

Suggested Readings:

1. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance, 2019, ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf
2. Chaddah, P., Ethics in Competitive Research: Do not get scooped; do not get plagiarized 2018, ISBN:978- 9387480865
3. Beall, J. Predatory publishers are corrupting open access, Nature, 489 (7415), 179-179, 2012. https://doi.org/10.1038/489179a
4. Resnik, D. B., What is ethics in research and why is it important, National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm 2011.
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A Guide to Responsible Conduct in Research: 3 rd edition , National Academics Press 2009.
6. Bird, A., Philosophy of Science, Routledge 2006.
7. MacIntyre, A., A Short History of Ethics, London 196

ADVANCED RELIABILITY THEORY

(SBS ST 02 01 01 E 6006)

Course Objectives:

The objective of the course is to enhance the knowledge of students to understand the theory as well as practical aspects of Reliability to deal with real life system complexities.

Learning Outcomes:

1. To understand concept of Reliability and Availability also distinguish between them.
2. To measure the reliability function and mean time to failure for different types of systems.
3. To study the life Time distribution and the concept of various reliability operations on it.
4. To study the concept and Analysis of life time data.

Unit I

Introduction to Reliability: Basic concepts and Reliability Measures, Types and Importance of reliability. Failures: Different Modes of Failure, Causes of Failures, Failure Rate, Hazard Function. Reliability in Terms of Hazard Rate and Failure Density Functions. Mean Time to System Failure (MTSF), Relation between MTSF and Reliability and related research articles.

Unit- II

System Components and Configurations: Series, Parallel, Series-Parallel, Parallel-Series, and K-out-of-N systems. Redundancy: Types of Redundancies, Repairable Systems, Coherent Structure: min paths and cut sets, modular decomposition, lower/upper bounds on system reliability. Reliability and Structural importance of components, Maintenance Policies; Availability: Definition and Types and related research articles.

Unit –III

Classes of Life distribution: IFR, IFRA, NBU and NBUE Classes and their duals, Closures of these classes under various reliability operations, Reliability of Safety Systems, Safety instrumented Systems, Probability of failure on Demand, Safety Unavailability, Common Cause Failures **and related research articles.**

Unit IV

Life Data Analysis: Concept of Censoring and its types, Reliability Estimation based on Failure Times in Censored Life Tests: Kaplan–Meier Estimation, Hazard Plotting Techniques, Maximum Likelihood Estimation and Probability Plotting Technique. Two-Unit Cold Standby and Parallel-Unit Systems with Constant Failure Rate, Arbitrary Repair Rates and a Single Server using Semi-Markov Process and Regenerative Point Technique **and related research articles.**

Suggested Readings:

1. Rausand, M., & Hoyland, A. (2009). System reliability theory: Models, statistical methods, and applications (2nd edition). Hoboken, NJ: Wiley-Interscience.
2. Barlow, R. E., & Proschan, F. (2007). Statistical theory of reliability and life testing: probability models. New York: Holt, Rinehart and Winston.
3. Balagurusamy, E. (2017). Reliability Engineering, Tata McGraw-Hill Education.
4. Birolini, A. (2017). Reliability Engineering, Springer-Verlag Berlin Heidelberg.

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BAYESIAN INFERENCE

(SPMS STAT 02 01 02 E 6006)

Course Objectives:

The objective of this course is to provide the sound knowledge of Bayesian estimation and the lifetime distribution methodology to students for the estimation regarding reliability characteristics of systems.

Learning Outcomes:

1. Describe the role of the posterior distribution, the likelihood function, prior and the posterior distribution about a parameter in Bayesian framework.
2. Understand inferences for lifetime models in Bayesian framework.
3. Learn the basic concepts of nonparametric techniques.
4. Understand the sequential probability ratio test and its application.

UNIT I

Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors **and related research articles.**

UNIT II

Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors **and related research articles.**

UNIT III

Parametric Empirical Bayes. Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference. Bayesian decision theory: Bayes solutions for practical decision problems. Point estimation, credible sets. Comparison with classical procedures **and related research articles.**

UNIT IV

Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof) **and related research articles.**

Suggested Readings:

1. Berger, J. O. (2013). Statistical Decision Theory and Bayesian Analysis. Springer.
2. Robert, C.P. & Casella, G. (2013). Monte Carlo Statistical Methods. Springer.
3. Kelly, D. & Smith, C. (2011). Bayesian Inference for Probabilistic Risk Assessment: A Practitioner's Guidebook. Springer.
4. Jeliazkov, I. & Yang, X.S. (2014). Bayesian Inference in the Social Sciences. Wiley.

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ORDER STATISTICS
(SPMS STAT 02 01 03 E 6006)

Course Objectives:

The objective of the course is to learn general strategies for problems about order statistics and how to learn to find the median (or k-th largest) in linear average-case number of comparisons (and time).

Learning Outcomes:

1. Understand the basic concepts of order statistics, joint, marginal and conditional probability distributions of order statistics.
2. Learn about distribution-free confidence intervals for population quantile and distribution-free tolerance intervals for population distributions.
3. Construct the recurrence relations and identities for moments of order statistics.
4. Enhanced with the concepts of distributions of order statistics for independently and not identically distributed variates and also for dependent variates.

UNIT I

Order statistics and their distributions and properties. Discrete & continuous joint, marginal and conditional distributions of order statistics. Censoring and progressive censoring, order statistics for independent and non-identically distributed variates. Example based on continuous distributions **and related research articles.**

UNIT II

Moments of order statistics, Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics, Recurrence relations and identities for moments of order statistics **and related research articles.**

UNIT III

Confidence intervals for distribution quantiles, tolerance limits for distributions. Asymptotic distribution of function of sample moments, U-Statistics, Transformation and Variance stabilizing results **and related research articles.**

UNIT IV

Generalized order statistics: distribution of generalized order statistics. Joint, marginal and conditional distribution of generalized order statistics. Moments and recurrence relations. Characterization of continuous distributions through conditional moments and recurrence relations of generalized order statistics. Review of latest literatures **and related research articles.**

Suggested Readings:

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables: Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publishers.

RELIABILITY AND LIFE TESTING

(SPMS STAT 02 01 04 E 6006)

Course Objectives:
The objective of this course is to provide lifetime distribution methodology to students for the estimation and testing of hypotheses regarding reliability characteristics of systems.
Learning Outcomes:

1. Understand basic concepts of reliability and life testing models.
2. Learn how to handle censored data under different scenarios.
3. Understand the testing of hypothesis and confidence interval for different life time models.
4. Learn how to obtain the Bayes estimators.

UNIT I

Definition of reliability function, hazard function, mean time to system failure and their relationship. Life testing plans or censoring methods, right and left censoring, Type I and II censoring schemes **and related research articles.**

UNIT II

Exponential, Gamma, Weibull and normal probability models as used in the analysis of life time data and in problems related to the modeling of aging or failure processes. Estimation of parameters and reliability function associated with various life time distributions and life testing plans, Various properties of these estimators **and related research articles.**

UNIT III

Test of hypothesis and confidence intervals for the parameters and reliability function of exponential, gamma, Weibull and normal distributions **and related research articles.**

UNIT IV

Bayes estimators of the parameters and reliability function under different loss functions associated with various life time distributions. Their properties and comparison with classical estimators **and related research articles.**

Suggested Readings:

1. Deshpande, J.V. & Purohit, S.G. (2016). Life Time Data: Statistical Models and Methods, 2nd Edition. Word Scientific.
2. Lawless, J.F. (2011). Statistical Models and Methods for Lifetime Data, 2nd Edition reprint. Wiley.
3. Zacks, S. (2011). Introduction to Reliability Analysis - Probability Models and Statistical Methods. Springer.
4. Lee, E.T. & Wang, J.W. (2015). Statistical Methods for Survival Data Analysis, 4th Edition. Wiley.

Guidelines for University Research Fellowship (URF)

1. Short Title, Application and Dissemination

(i) The Central University of Haryana (CUH) hereby notifies the following guidelines which shall be called "Guidelines for University Research Fellowship". They shall come into force immediately after their formal notification on University website.

(ii) The Scheme of the URF is applicable for Ph.D. scholars who are not in receipt of any financial assistance from any source and are registered in various Centers of the University. The award and extension of fellowship will always be subject to actual release of funds and directives from the UGC and/or MoE issued from time to time.

2. Eligibility, Nature of Assistance under the Scheme and Duration of Award:

(i) The maximum span period for award of URF shall be 03 years for Ph.D. starting from date of admission and extendable by 01 year after the recommendation of the DRC or upto completion of viva voce / submission of dissertation where viva voce is not conducted, whichever is earlier.

(ii) If a scholar drawing URF from the University leaves his course of study mid-way without undertaking proper formalities with regard to cancellation of admission laid down by the University, the total fellowship drawn by him until that point of time shall be recovered from him by the University.

(iii) Scholars, who have been registered under Ph.D. programme and availing fellowship under projects and are not availing any fellowship after the project is over or in case of mid-term discontinuation, shall be considered for URF. However, in such cases, the maximum period of fellowship shall not exceed the period prescribed by UGC and duration of fellowship from the project shall be counted towards the total duration of URF from the date of admission in the program concerned.

Such application should be received in the Finance Branch within three (03) months from the date of expiry of project fellowship after due recommendation by DRC specific to the scholar constituted as per the relevant ordinances of the University. Application received after this date shall not be entertained.

(iv) Amount and duration of fellowship:

S.No.	Particular	Fellowship Amount	Duration of Fellowship
1	Fellowship for Full Time Ph.D.	₹ 8000/- Per Month	For a period of 3 years and extendable by one year.
2	Contingency	₹ 10000/- per annum for Sciences. ₹ 8000/- per annum for Humanities and Social Science.	

(Note: No House Rent Allowance (HRA) is admissible to the Scholar under URF)

3. Standard Operating Procedures:

(i) Award shall commence from the date of Admission of the Scholar.

(ii) The proforma should be complete in all respects otherwise it will not be accepted in the Finance Branch.

(iii) A copy of Admission proof and a copy of passbook (self-attested) shall be submitted to the Finance Branch by the fresh scholars with their first claim.

(iv) Fellowship will be processed on monthly basis and Fellowship claims shall be submitted by scholars duly filled in proforma given at **Annexure-1** to their respective Supervisors for processing and verification. Supervisors shall scrutinize the claims carefully ascertaining the eligibility of scholars for fellowship as per the provisions laid down in these guidelines. Supervisors as applicable, shall forward the fellowship claims with satisfactory remarks to their respective HODs who in turn will submit all bills at once to finance branch for better administrative efficiency and timely disposal of bills.

(v) Attendance and Leave record of scholars shall be maintained by the supervisors under supervision of HoD. Progress report and Attendance report are not required in the Finance branch.

(vi) The documents with regard to the claims for a particular period shall reach by the 7th day of each month to the Finance Branch, which, in turn, shall release the fellowship amount to the scholars before 15th of every month if funds are available.

(vii) Contingency claims will be processed on yearly basis. Contingency claims duly filled and forwarded by concerned Supervisor in proforma given at **Annexure-2** along with valid and verified bills shall be submitted to their respective HoDs. Stock entries shall be verified by the concerned supervisor before forwarding the contingency claims to the Finance Branch. There should be a single contingency stock register at department level to be maintained by all research scholars under supervision of respective HoDs. The scholars will verify each and every bill and concerned supervisors will certify it with their signature and stamp. Such claims, duly verified and certified, shall be forwarded to Finance Branch by the 15 January (to avoid any clash with financial year closing) which, in turn, shall release the contingency amount to scholars on availability of funds. Unutilized contingency grant shall not be carried forward to next year under any circumstances. However, eligible scholars of M.Phil. Program shall be entitled to draw half contingency grant for the second financial year.

(viii) Fellowship claim for the pending period of more than two months will not be accepted in the Finance Branch.

(ix) **Utilization of contingent grant for the following:**

a. Acquisition of books and documents of relevance to the research topic provided these are not available in the library of the University. Certification from the Central Library is required in this case.

b. Chemical/consumable items required for the research work.

c. Equipment required exclusively for research.

d. Photographic material for thesis work.

e. Computation charges and computer related peripherals (Hard disc/ pen-drive, mouse etc.) provided certification by the concerned supervisor.

f. Reprints/off-prints of research papers.

g. Stationary and postal charges.

h. Typing of research papers if computer facility is not available in the host institution.

i. Thesis submission fee, life membership fee of reputed societies of respective subjects and registration fee of seminar/workshop etc.

Note: Contingent grant cannot be used for TA/DA claim, foreign travel or other expenses for visit abroad and furniture items.

4. Leave:

(i) Maximum leave period for scholars shall be thirty (30) days and five (05) days for Medical leave in a year excluding public holidays. They shall not be entitled to any vacation.

(ii) Women candidates are eligible for Maternity Leave/Child Care Leave of two hundred and forty (240) days at full rates of fellowship provided they meet the criteria of attendance.

(iii) In special cases, a University Research Fellow is permitted leave up to one year during entire span of fellowship for accepting only temporary teaching assignments within the city without fellowship. Such leave shall not be granted for Teaching/Job/ Research etc. assignments outside city/abroad. The duration of any leave granted shall be counted towards total span period of fellowship. The leave duly recommended by the concerned supervisor shall be forwarded to Scholarship Cell well in advance. Department shall maintain leave records.

(iv) Scholars shall proceed on leave for specific purposes only after explicit permission of their research supervisors and HOD/Dean, as applicable. Any unauthorized leave shall be treated as constituting grounds for disciplinary action.

5. Cancellation of Fellowship:

(i) The fellowship award is liable for cancellation in following cases:-

a. Misconduct
b. Unsatisfactory progress report and recommendation of cancellation by the DRC.
c. Scholar furnishes misleading information or hides any information to claim eligibility for fellowship and later found ineligible.
d. Scholar taking unauthorized leave other than what is admissible.

(ii) Before arriving at a decision in such matters, the University shall afford an opportunity to the scholar concerned to clarify his position and bring facts to its notice.

Note: These guidelines supersede all notifications/orders/circulars issued earlier on Non-NET fellowship scheme by the University.

Annexure-XVI

School of Interdisciplinary and Applied Sciences
Central University of Haryana
Mahendergarh (Haryana) 123031

Date: 04/10/2022 Time: 10.30 AM

The school board meeting was held in online mode at 10.30 AM on 04.10.2022. Following members joined the meeting

1. Prof. Neelam Sangwan, Dean SIAS (Chairperson)
2. Prof. HS Balyan (External expert)
3. Prof. DP Pathak (External expert)
4. Dr. GD Sharma (External expert)
5. Prof. D. Mohanty (External expert)
6. Prof. Bijender Singh
7. Prof. Gunjan Goel
8. Prof. Surender Singh
9. Prof. Vikas Beniwal
10. Dr. Avijit Pramanik
11. Prof. Pawan Kumar Maurya
12. Dr. Antresh Kumar
13. Dr. Saurabh Chandra Saxena
14. Prof. Kanti Prakash Sharma
15. Dr. Umesh Kumar
16. Dr. Mona Sharma
17. Prof. Dinesh Kumar Gupta
18. Mr. Amit
19. Dr. Dinesh Kumar
20. Dr. Sumit Kumar

Prof. Neelam Sangwan, Dean SIAS and Chairperson of the school board welcomed all the members of School Board. She apprised of the recent developments at the School of Interdisciplinary and Applied Sciences. Following agenda items were discussed and resolved in the school board meeting:

Agenda 1: To consider the recommendations of Board of Studies dated 24.05. 2022 of Department of Microbiology, for revision of scheme and syllabi for the Ph.D. Microbiology

Resolution: The members discussed the revised syllabi and recommended to include new topics in unit –II of "Research Methodology" course as recommended by BoS of Biotechnology to align it in school mode. Topic on "multiple range tests" is also to be added after t-test, as suggested.

In unit II of course Advanced Analytical Techniques, topic on "Introduction and overview of Metabolomics" is to be added, as suggested.

In unit II of course "The Microbiome" topic on Overview of online tools and databases for microbiome analysis is to be added as suugested.

Agenda 2. To consider the recommendations of Board of Studies dated 28.06.2022 of Department of Biotechnology, for revision of scheme and syllabi for the Ph.D. Biotechnology

NSSangwan 4/10/2022

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S.
Dean
School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh - 123031, Haryana, India

Bijender Singh 6/10/22

6/10/22

6/10/22

6/10/22

6/10/22

6-10-22

04/10/2022

6/10/22

Resolution: The members discussed the revised syllabi and recommended to include the topics suggested by BoS of other departments for courses Research Methodology and Advanced Analytical Techniques in order to align their syllabi with other departments (Microbiology, Biochemistry, Environmental Sciences) of school.

Agenda 3: To consider the recommendations of Board of Studies dated 17.05.2022 of Department of Biochemistry, for revision of scheme and syllabi for the Ph.D. in Biochemistry

Resolution: The members discussed the revised syllabi and recommended to include the topics suggested by BoS of other departments for courses Research Methodology and Advanced Analytical Techniques in order to align their syllabi with other departments (Microbiology, Biotechnology, Environmental Sciences) of school.

Agenda 4: To consider the recommendations of Board of Studies dated 30.05.2022 of Department of Environmental Studies, for scheme and syllabi for the Ph.D. Environmental Sciences

Resolution: The members discussed the syllabi for Ph.D. Environmental Sciences and recommended to include the topics suggested by BoS of other departments for courses Research Methodology and Advanced Analytical Techniques in order to align their syllabi with other departments (Microbiology, Biotechnology, Biochemistry) of school.

Agenda 5: To consider the recommendations of Board of Studies dated 30.05.2022 of Department of Environmental Studies, for change of name of Department of Environmental Studies to Department of Environmental Sciences

Resolution: The members recommended to change of the name of Department of Environmental Studies to Department of Environmental Sciences

Agenda 6: To consider the recommendations of Board of Studies dated 13.05.2022 of Department of Pharmaceutical Sciences, for scheme and syllabi as per Learning outcome-based framework [LOCF] for M. Pharm. (Pharmacology) in the Department of Pharmaceutical Sciences

Resolution: The members discussed the syllabi and recommended to increase the credit load to 96 credits in order to maintain the uniformity in the school.

Agenda 7: To consider the recommendations of Board of Studies dated 13.05.2022 of Department of Pharmaceutical Sciences, for scheme and syllabi as per Learning outcome-based framework [LOCF] for M. Pharm. (Pharmacognosy) in the Department of Pharmaceutical Sciences

Resolution: The members discussed the syllabi and recommended to increase the credit load to 96 credits in order to maintain the uniformity in the school.

Further, following suggestions were made by external expert member:

1. To look into the possibility of writing thesis in Hindi, if so desired by the research scholar, specially in certain subjects/area where it may benefit larger section of the society,
2. To include "Biochemical impact of Yogic Practices" may be included the Syllabus of Biochemistry (DCEC)

Meeting ended with the thanks to the Chairperson, external experts and all the members.

1. Prof. Neelam Sangwan, Dean SIAS (Chairperson)
2. Prof. HS Balyan (External expert)
3. Prof. DP Pathak (External expert)
4. Dr. GD Sharma (External expert)
5. Prof. D. Mohanty (External expert)
6. Prof. Bijender Singh Bijender Singh
7. Prof. Gunjan Goel
8. Prof. Surender Singh
9. Prof. Vikas Beniwal
10. Dr. Avijit Pramanik
11. Prof. Pawan Kumar Maurya
12. Dr. Antresh Kumar
13. Dr. Saurabh Chandra Saxena
14. Prof. Kanti Prakash Sharma
15. Dr. Umesh Kumar 06/10/22
16. Dr. Mona Sharma
17. Prof. Dinesh Kumar Gupta
18. Mr. Amit
19. Dr. Dinesh Kumar
20. Dr. Sumit Kumar Sumit Kumar 06/10/2022

Central University of Haryana
School of Interdisciplinary and Applied Sciences
Department of Microbiology

SCHEME AND CURRICULUM

Ph.D. Microbiology
(w.e.f. 2022)

6/10/2022

06/10/22

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S.
Dean
School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh - 123031, Haryana, India

Department of Microbiology

CENTRAL UNIVERSITY OF HARYANA
MAHENDERGARH, HARYANA

SCHEME AND CURRICULUM

Ph.D. Microbiology

Semester	Core /Elective	Paper Code	Title of the Paper	Credit
I	Core	SIAS MB 02 01 01 C 4004	Research Methodology	4
	Core	SIAS MB 02 01 02 C 4004	Advanced Analytical Techniques	4
	Core	SIAS MB 02 01 03 C 2002	Research and Publication Ethics (RPE)	2
	Elective	SIAS MB 02 01 01 E 4004	Advanced Immunology	4
	Elective	SIAS MB 02 01 02 E 4004	Microbial Metabolism	4
	Elective	SIAS MB 02 01 03 E 4004	The Microbiome	4
	Total			**14**

Course: Research Methodology
Course code: SIAS MB 02 01 01 C 4004

Credit: 4

Lectures: 60

Course objective: To provide knowledge about tools and techniques related with scientific communication, research methodology and biosafety in biological experiments.

Learning outcomes:

- Understanding the existence of scientific knowledge in ancient times
- Acquiring the skills of scientific reading, writing and presentations
- Appreciating the scientific ethics through case studies
- Understand the importance and level of biosafety at laboratory and industrial levels

Unit 1. Identification and defining of the Research Problem:
Familiarization of research areas; Review of literature using appropriate resources – reviews, research papers, books and patents; Use of tools for searching literature through electronic databases; Defining a research problem.

Unit 2. Experimental Approaches and Methodology
Experimental designs to address the research problem; Pros and cons of different experimental strategies; Finalization of experimental design; Tools and techniques to execute experiments; Means to validate and analyze data; Use of statistical tools for analyzing the significance and interpretation of the data; Measurement of central tendencies (Mean, Median, Mode); Measurement of variability (standard deviation, standard error of mean, range, mean deviation, coefficient of variation). Levels of significance; regression and correlation; t-test; Multiple range test; analysis of variance; chi square test.

Unit 3. Ethics and Safety in Biological Research
Guidelines for Biosafety and Bioethics; Institutional Biosafety Committee – Handling of Genetically modified organisms, Institutional Human and Animal Ethics Committee - compliance, concerns and approval; Safety practices and disposal of Bio-waste in the laboratory; Radioactivity and safety precautions; Handling and disposal of flammable and hazardous chemicals.

Unit 4. Presentation, Publication and Protection of Research Data
Development of skills for scientific writing and research presentation – Term paper, Research project, Research report, Thesis, Research article and Review; Organization of the research document in to different sections (Introduction, Methodology, Results, Discussion, and Summary and Conclusions, Bibliography); Use of electronic tools for bibliographic formatting and checking Plagiarism; Development of Oral presentation skills; Patents and Intellectual property rights.

Students are expected to undertake the following assignments, exercises for evaluation.

1. Identification and selection of the broad area of research
2. Review of literature, formulation of research plan and submission of term paper along with references
3. Oral presentation of research plan and experimental design

Evaluation will be based on term paper and oral presentation

Suggested readings

1. Communicate Science Papers, Presentations, and Posters Effectively (2015) Patience GS, Boffito DC, Patience P, Academic Press, ISBN: 978-0128015001.
2. Research Methodology: Methods And Techniques (2019) 4th ed., Kothari CR and Garg G, New Age International Publishers, ISBN: 978-9386649225.
3. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (2014) 4th ed., Matthews JR and Matthews RW, Cambridge University Press ISBN: 978-1107691933.
4. Doing Science: Design, Analysis, and Communication of Scientific Research. (2001) Valiela I, Oxford: Oxford University Press, ISBN 10:019538573X.
5. Beauchamp T.L., Walters L., Kahn J.P. & Anna C. Contemporary issues in Bioethics. Wardsworth Publishers. Co. 2013. Print
6. Cross C.L. and Wayne W.D. Biostatistics: Basic Concepts and Methodology for the Health Sciences. 10th edition, Wiley. 2014. Print
7. Davis, G.B. and Straub D.W. Writing the doctoral dissertation. 3rd edition. Barron's Educational series. 2012. Print
8. Deepa Goel. IPR, Biosafety and Bioethics.1st edition. Pearson Education. 2013. Print
9. Krishnaswamy, K.N., Mathiranjan M., and Sivakumar, A.I. Management Research Methodology; Integration of Principles, Methods and Techniques. Pearson Education. 2011. Print
10. Montgomery, Douglas C. Design and Analysis of Experiments. 8th edition. Wiley. 2013. Print
11. Rao S and Richard J. Introduction to Biostatistics and Research Methods. 5th edition. Prentice Hall India Learning Private Limited. 2012. Print
12. IPR, Biosafety and Bioethics (2013) Parashar S, Goel D, Pearson Publishing India, ISBN: 9788131774700.
13. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology
(2017) Nambisan P, Academic Press, ISBN: 9780128092316.
14. http://dbtindia.gov.in/guidelines-biosafety

Course: Advanced Analytical Techniques
Course code: SIAS MB 02 01 02 C 4004

Credit: 4

Lectures: 60

Course objective: To provide an advanced understanding of the core principles of various techniques used in biological experiments.

Learning outcomes:

- Demonstrate principles of various basic and advanced techniques used in biological experiments
- Critically analyze and interpret the results obtained from biological experiments

Unit 1. Recombinant DNA techniques and Genomics

Use of Restriction and modification enzymes in cloning; Plasmid vector; Transformation and Plasmid isolation; PCR; DNA sequencing methods (Sanger's chain termination method, and automated DNA sequencing); Next generation sequencing (NGS); Global expression profiling; Whole genome analysis of mRNA and protein expression; Real time PCR and Microarrays and their applications

Unit 2. Proteomics and Nanotechnology

UV and fluorescence spectroscopy; Circular Dichroism; Mass spectrometry - Principles and their applications; Protein separation techniques and instrumentation (Gel filtration, Ion exchange and Affinity chromatography, 1D and 2D Polyacrylamide gel electrophoresis); Immunochemical detection of proteins.; Introduction and overview of Metabolomics; Nanotechnology and its Applications in pharmaceutical Industry, Agriculture, Food Industry, Manufacturing Industry, and Renewable Energy Sector.

Unit 3. Microbial and Cellular Techniques

Microscopic techniques; Microbial growth and kinetics (synchronous culture, continuous and batch and fed-batch cultures, chemostat and turbidostat); Methods for identifying microbes (polyphasic approach); Cell disruption and fractionation of organelles; Isolation and purification of membrane proteins; Various methods to study cell-cell and cell-virus fusion; Flow cytometry techniques; Confocal and Atomic Force Microscopy; Types of Biosafety cabinets

Unit 4. Experimental Models and instrumentation in Biology

Rodent and non-rodent models, worms as models for studying human-microbe interactions, Handling and maintenance of animals, Ventilated cages, Different routes of injections and collection of various biological components, Formulation of feed and design of experiments. Principle, instrumentation and environmental applications of Neutron Activation Analysis, X- Ray Fluorescence, X-Ray Diffraction, AAS, Hyphenated techniques-LC-MS/MS, GC-MS/MS, HPTLC-MS, ICP-MS.

Suggested readings

1. Ausubel FW. Current Protocols in Molecular Biology. Wiley-Blackwell. 2011. Print
2. Burgess R. and Deutcher MP. Guide to Protein Purification. Academic Press, San Diego, USA. 2009. Print

3. Butler, M. Animal Cell Culture & Technology. 1st edition. Tailor & Francis Publishers (UK). 2004. Print
4. Freshney, R.I. Culture of Animal cells: A Manual of Basic Technique and specialized applications. 7th edition. Wiley-Blackwell. 2016. Print
5. Green M.R. and Sambrook J. Molecular Cloning: A Laboratory Manual. Vol. I, II, III. 4th edition. Cold spring harbor laboratory press. 2013. Print
6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
7. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
8. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
9. Instrumental methods of analysis (1988) 7th ed. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle (United States).
10. D.S. Goodsell 2013 Bionanotechnology: Lessons From Nature, John Wiley
11. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. Tata McGraw Hill, 1994.
12. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. Cengage India, 2015.

Course: Research and Publication Ethics
Course code: SIAS MB 02 01 03 C 2002

Credit: 2

Lectures: 30

Course objective: To learn philosophy of science, research misconduct and integrity, publication plagiarism and ethics.

Learning Outcomes:

- Learn to identify the FFP in research and ethics of publication.
- Hands on session help to find research misconduct, predatory publication, publications metrics and plagiarism.
- To learn database citation and indexing of publication.

Part A: THEORY

Unit1 Philosophy & ethics

Introduction of Philosophy; definition, nature and scope, concept, branches. Ethics; definition, moral philosophy, nature of moral judgments and reactions.

Unit II Scientific Conduct

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific Misconduct; falsification, fabrication and Plagiarism (FFP), Redundant publications; duplicate and overlapping publications, salami slicing.

Unit III Publication Ethics

Publication ethics; definition, introduction and importance. Best Practices/ standards setting initiatives and guidelines: COPE, WAME etc., Conflict of Interest, Publication misconduct: definition, concept, problems lead to unethical behavior and vice-versa, types, Violation of publication ethics, authorship and contributor-ship, Identification of publication misconduct, complaint and appeals, Predatory publications and journals.

Part B: PRACTICE

Unit IV Open Access publishing

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-achieving policies, Software tools to identify predatory publications developed by SPPU, Journal finder Journal suggestion tools vis. JANE, Elsevier journal finder, Springer journal suggester etc.

Unit V Publication Misconduct

Group discussion; Subject specific ethical issues, FFP, Authorship, Conflict of interest, Complaint and appeals; example and fraud from India and abroad. Software tools; turnitin, urkund and other open source plagiarism tools.

Unit VI Database and Research Metrics

Database: Indexing citation database; Web of Science and Scopus etc., Research metrics; Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score, Metrics; h index, g index, i10, altmetrics.

Course: Advanced Immunology
Course code: SIAS MB 02 01 01 E 4004

Credit: 4

Lectures: 60

Course objective: To understand overall organization of the immune system and to identify the cellular and molecular basis of immune responsiveness.

Learning outcomes:

- Understanding the working mechanism of the immune system
- Understanding of antibody, MHC, complement system, cytokines, cancer, and organ transplant hypersensitivity

Unit 1. Receptors of the immune cells
Detailed structure of B and T cell receptors, co-receptors and accessory proteins; Structural features of CD4, CD8 receptors and; Cellular adhesion molecules *viz.* ICAM, VCAM, MadCAM, selectins and integrins; Structure and distribution of Major Histocompatibility Complex I and II and their interaction with antigens; Markers of suppressor / regulatory cells *eg.* $CD4^+$ $CD25^+$ $Foxp3^+$ T_{reg}; Natural killer T cells (NKT)

Unit 2. Genetic organization of the receptor genes:
Genetic organization of B and T cell receptors coding genes; Genetic organization of MHC-I and MHC-II complex (both HLA and H-2); Mechanisms responsible for generating antibody diversity and diversity of T cell receptor specificities

Unit 3. Mechanisms of Immune recognition and response:
Detailed mechanisms of humoral and cell-mediated immune responses; Antigen presentation by MHC-I and MHC-II molecules; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, 1L-10, 1L-12, IL-17, TGFβ; Complement System; Pattern recognition receptors (PRRs) and Toll-like receptors (TLR); Cell signaling through NF-κB; Natural Killer - Dendritic cells (NK-DC) interactions; CD-1 restricted T cells;

Unit 4. Applied Topics in Immunology:
Autoimmune diseases induced by microbes; Deficiencies / defects of T cells and B cells; Mucosal immunology; Comparative analysis of type I-IV hypersensitivities; Alloreactive T cells; Graft rejection and GVHD; Sequence based HLA-matching; Immunodiagnostics; CRISPR-Cas9 system and transgenic animals for xenotransplantation; Immunotherapy for tumors in humans

SUGGESTED READINGS

1. Kuby Immunology (2018) 8th ed., Punt J, Stranford S, Jones P and Owen JA, W.H Freeman and Company, ISBN: 978-1319114701.
2. Janeway's Immunobiology (2017) 9th ed., Murphy KM and Beaver C, WW Norton and Company, ISBN: 978-0815345510.
3. Roitt's Essential Immunology (2017) 13th ed., Delvis PJ, Martin SJ, Burton DR and Roitt, IM, Wiley-Blackwell, ISBN: 978-1118415771.

4. Lehninger: Principles of Biochemistry (2017) 7th ed., Nelson, DL and Cox, MM, WH Freeman and Company (New York), ISBN: 978-1319108243.
5. Lippincott's illustrated Reviews Immunology (2012) 2nd ed., Doan T, Melvold R, Viselli S and Waltenbaugh, C, Wolters Kluwer India Pvt, Ltd, ISBN: 978-8184737639.

Course: Microbial Metabolism
Course code: SIAS MB 02 01 02 E 4004

Credit: 4

Lectures: 60

Course objective: The course is designed to describe metabolic and physiological diversity among prokaryotes.

Learning outcome:

- Learning of principles of microbial catabolic and anabolic pathways
- Understanding the transport systems and the mechanisms of energy conservation in microbial metabolism
- Identifying various physiological groups of bacteria with their special features

Unit 1. Microbial growth and growth kinetics:
Bacterial growth curve, generation time, measurement of microbial growth, growth kinetics, synchronous culture, continuous and batch culture, chemostat and turbidostat, environmental factors that affect growth, nutritional diversity in bacteria; Nutrient transport in microbes - Active and passive transport, Primary and secondary transport, Transport kinetics, ABC transporter, PEP-PTS system

Unit 2. Diversity and regulation of glucose metabolism in microbes:
Embden-Meyerhof-Parnas pathway; Variations of EMP pathway in different groups of bacteria; Overall energy balance sheet; Regulation of the EMP pathway; Modes of NAD regeneration; Pentose phosphate pathway – HMP pathway and its link with glycolysis; Fermentative mode of glucose oxidation - Entner-Doudoroff pathway; Variations of ED pathway in different groups of microbes and its implications; Fates of pyruvate; Alcoholic and lactic acid fermentation; Citric acid pathway – Stoichiometry and energy gain; Regulation; Alternate forms of TCA - Reductive TCA, Branched TCA; Glyoxylate cycle

Unit 3. Nitrogen metabolism:
Nitrogen assimilation; GS-GOGAT pathway and its regulation; Utilization of other modes of nitrogen, nitrate and nitrite utilization; amino acid biosynthetic pathways and their regulation; Amino acid utilization – reductive amination and deamination, decarboxylation; Stickland reaction; Amino acid oxidases, Polyamine biosynthesis and utilization

Unit 4. Metabolic engineering:
Introduction to primary and secondary metabolism; Classification of secondary metabolites; Introduction to metabolic engineering – strain development and pathway engineering; Case studies on primary metabolites *viz.* citric acid, succinic acid, lactic acid, ethanol fermentation, amino acid pathways (glutamate, lysine, shikimic acid); Case studies on secondary metabolites viz. polyhydroxyalkanoates, polyketides and antibiotics

Suggested Readings

1. Albert G. Moat, John W. Foster, Michael P. Spector. *Microbial Physiology*. 4th edition. John Wiley & Sons. 2002. Print

2. Michael M. Madigan, Kelly S. Bender, Daniel H. Buckley, W Matthew Sattley, David A. Stahl, 15th edition, 2018, ISBN-13: 9780134261928 Pearson publications
3. Stanier RY, Adelberg EA, Ingraham JL. *General Microbiology*. 4th edition. Macmillan Press, London. 1976. Print
4. An Introduction to Microbiology (2019), 3rd ed., Tauro P, Kapoor KK, Yadav KS, and Sequeira MG, New Age International Publishers. ISBN: 0852268785
5. Microbial Biochemistry (2014) Cohen GN, 3rd edition. Springer Netherlands. ISBN 978-90-481-9437-7
6. The Physiology and Biochemistry of Prokaryotes. (2011) White D, Dummond J and Fuqua, C, 4th edition. Oxford University Press. ISBN: 9780195393040
7. Prescott's Microbiology (2017) 10th ed., Willey J, Sherwood L and Woolverton CJ. McGraw-Hill Education, ISBN: 1259281590
8. A text book of Microbiology (2013), Dubey RC and Maheswari, DK Revised S. Chand and Company Ltd, New Delhi. ISBN: 9788121926201

Course Title: The Microbiome
Course Code: SIAS MB 02 01 03 E 4004

Credit: 4

Lectures: 60

Unit-I

History of the study of the microbiome; designing a microbiome study (hypotheses, methods, technologies); methods to study microbiome- DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods; Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome; Overview of online tools and databases for microbiome analysis.

Unit-II

Techniques used to analyse microbiome data- assignment of taxonomy; generating OTU tables, quality control: Describing the complexity of the microbiome eg. alpha and beta-diversity; comparing microbial communities, phylogenetic trees, UniFrac, principal coordinate analyses, Venn diagrams, heat maps; development of new bioinformatics methods for microbiome studies. Functional studies of the Microbiome- Measurement of microbial products (the metabolome, proteome and glycome; role of microbiome and its products, nutrition, metabolism, the gut brain axis, and in immune-inflammatory processing.

Unit-III

Introduction to the Human Microbiome; The Human Microbiome Project (HMP); Diversity of the Human Microbiome- Oral microbiome, Gut microbiome, Skin microbiome, Vaginal microbiome; Gut microbiome changes in various diseases including liver diseases, obesity, diabetes, and other disorders; the mycome and virome in health and disease. Direct health effects of gut microbiome; modification of the microbiome- Effects of antibiotics, probiotics and prebiotics. Faecal transplant; microbiome in treatment of diseases.

Unit-IV

The plant microbiome: structure and function: above and below ground plant microbiome. Plant microbiome engineering to improve plant health. Soil microbiome- Structure, functions and its manipulation for better soil health. Rumen microbiome: composition, abundance and diversity. Animal behavior and the microbiome. Environmental microbiome; Insect gut microbiome-structure and ecological importance. Microbiomes of the built environments; Human health and microbiomes of the built environment.

Suggested readings:

1. Unravelling the Soil Microbiome: Perspectives for Environmental Sustainability (2020) 1st ed., Dubey RK, Tripathi V, Prabha R, Chaurasia R, Singh DP, Rao CS, El-Keblawy A and Abhilash PC, Springer Cham, ISBN: 978330155155.

Um GB

2. Microbiome and Metabolome in Diagnosis, Therapy and other strategic Applications (2019) 1st ed., Faintuch J and Faintuch S. Academic Press (New York) ISBN: 9780128152492.
3. Diet, Microbiome and Health (2018) 1st ed., Holban AM, Grumezescu AM. Academic Press (New York), ISBN: 9780128114407.
4. Functional importance of the plant microbiome: Implications for agriculture, forestry and bioenergy (2017) 1st ed., Doty SL. Springer Cham. ISBN: 978-3-319-65896-4.
5. Microbiome Analysis: Methods and Protocols. (2018) 1st ed., Beiko RG, Hsiao W and Parkinson J. Springer New York. ISBN: 9781493987269.
6. The Gut Microbiome in Health and Disease (2018). 1st ed., Haller D. Springer International Publishing. ISBN 978-3-319-90544-0.

Annexure-XVII

Course Curriculum and Scheme of Examination

Under Choice Based Credit System

For Ph.D. Biotechnology Course Work

Session 2022-2023

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S
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School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh - 123031, Haryana, India

Department of Biotechnology

School of Interdisciplinary and Applied Sciences

Central University of Haryana

Mahendergarh-123031, Haryana

Course work for Ph. D. in Biotechnology

Scheme and Syllabus (w.e.f. Session 2022-23)

Semester-I

Course code	Course title	L	T	P	Type of course	Credit
SIASBT 02 01 01 C 4004	Research Methodology	4	0	0	Core	4
SIASBT 02 01 02 C 4004	Advanced Analytical Techniques	4	0	0	Core	4
SIAS BT 02 01 03 C 2002	Research and Publication Ethics	2	0	0	Core	2
SIAS BT 020 1 01 DCEC 4004	Omics Technologies*	4	0	0	DCEC	4
SIAS BT 020 1 02 DCEC 4004	Advances in Genetic Engineering*	4	0	0	DCEC	4
Total Credit						14

*One course to be selected by the student

<table>
<tr><td colspan="4">Course Name: Research Methodology</td><td colspan="4">Course Code: SIAS BT 02 01 01 C 4004</td></tr>
<tr><td rowspan="2">Batch:
2022-2023</td><td rowspan="2">Programme:
Ph.D. Course work in Biotechnology</td><td rowspan="2">Semester : I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs. per Week: 04</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td><td>Total Hrs.: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100
CIE: 40 Marks
TEE: 60 Marks</td><td colspan="6">Examination Duration: 3 Hrs.</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide knowledge about tools and techniques related with scientific communication, research methodology and biosafety in biological experiments.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">• Understanding the existence of scientific knowledge in ancient times
• Acquiring the skills of scientific reading, writing and presentations
• Appreciating the scientific ethics through case studies
• Understand the importance and level of biosafety at laboratory and industrial levels</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE: Total eight questions will be set from entire syllabus. Students are advised to attempt any five questions. Each question carries twelve marks.</td></tr>
</table>

Unit No.	Contents	Contact Hrs.
I	**Identification and defining of the Research Problem** Familiarization of research areas; Review of literature using appropriate resources – reviews, research papers, books and patents; Use of tools for searching literature through electronic databases; Defining a research problem.	15
II	**Experimental Approaches and Methodology** Experimental designs to address the research problem; Pros and cons of different experimental strategies; Finalization of experimental design; Tools and techniques to execute experiments; Means to validate and analyze data; Use of statistical tools for analyzing the significance and interpretation of the data; Measurement of central tendencies (Mean, Median, Mode); Measurement of variability (standard deviation, standard error of mean, range, mean deviation, coefficient of variation). Levels of significance; regression and correlation; t-test; multiple range test, analysis of variance; chi square test.	15
III	**Ethics and Safety in Biological Research** Guidelines for Biosafety and Bioethics; Institutional Biosafety Committee – Handling of Genetically modified organisms, Institutional Human and Animal Ethics Committee - compliance, concerns and approval; Safety practices and disposal of Bio-waste in the laboratory; Radioactivity and safety precautions; Handling and disposal of flammable and hazardous chemicals.	15
IV	**Presentation, Publication and Protection of Research Data** Development of skills for scientific writing and research presentation – Term paper, Research project, Research report, Thesis, Research article and Review; Organization of the research document in to different sections (Introduction, Methodology, Results, Discussion, and Summary and Conclusions, Bibliography); Use of electronic tools for bibliographic formatting and checking Plagiarism; Development of Oral presentation skills; Patents and Intellectual property rights.	15

NOTE: Students are expected to undertake the following assignments, exercises for evaluation:

- Identification and selection of the broad area of research
- Review of literature, formulation of research plan and submission of term paper along with references
- Oral presentation of research plan and experimental design
- Evaluation will be based on term paper and oral presentation

Suggested Readings:

1. Biostatistics: Basic Concepts and Methodology for the Health Sciences (2014) 10th ed., Cross CL and Wayne WD, Wiley, ISBN: 978-8126551897.
2. Writing the doctoral dissertation (2012) 3rd ed., Davis GB and Straub DW. Barron's Educational series, ISBN: 978-0764147876.
3. Research Methodology: A Step-by-Step Guide for Beginners (2005) 2nd ed., Kumar R. Pearson Education. ISBN: 978-1446269978.
4. How to write and publish a scientific paper (2011) Gastel B and Robert AD. 7th ed. Greenwood, ISBN: 978-0313391972.
5. IPR, Biosafety and Bioethics (2013) 1st edi., Goel D and Parashar S. Pearson Education. ISBN: 978-8131774700
6. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) Nambisan P, Academic Press, ISBN: 9780128092316.
7. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India.http://www.ipindia.nic.in/

Course Name: Advanced Analytical Techniques					Course Code: SIAS BT 02 01 02 C 4004		
Batch: 2022-2023	**Programme:** Ph.D. Course work in Biotechnology	**Semester : I**	**L** 4	**T** 0	**P** 0	**Credits** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 40 Marks **TEE:** 60 Marks		**Examination Duration:** 3 Hrs.					
Course Objective	To provide an advanced understanding of the core principles of various techniques used in biological experiments						
Course Outcomes:	• Demonstrate principles of various basic and advanced techniques used inbiological experiments • Critically analyze and interpret the results obtained from biological experiments						

COURSE SYLLABUS

NOTE: Total eight questions will be set from entire syllabus. Students are advised to attempt any five questions. Each question carries twelve marks.

Unit No.	Contents	Contact Hrs.
I	**Recombinant DNA techniques and Genomics** Use of Restriction and modification enzymes in cloning; Plasmid vector; Transformation and Plasmid isolation; PCR; DNA sequencing methods (Sanger's chain termination method, and automated DNA sequencing); Next generation sequencing (NGS); Global expression profiling; Whole genome analysis of mRNA and protein expression; Real time PCR and Microarrays and their applications	15
II	**Proteomics and Nanotechnology** UV and fluorescence spectroscopy; Circular Dichroism; Mass spectrometry - Principles and their applications; Protein separation techniques and instrumentation (Gel filtration, Ion exchange and Affinity chromatography, 1D and 2D Polyacrylamide gel electrophoresis); Immunochemical detection of proteins. Introduction and overview of Metabolomics; Nanotechnology and its Applications in pharmaceutical Industry, medical science and healthcare, Agriculture, Food Industry, Consumer applications, and Renewable Energy Sector.	15
III	**Microbial and Cellular Techniques** Microscopic techniques; Microbial growth and kinetics (synchronous culture, continuous and batch and fed-batch cultures, chemostat and turbidostat); Methods for identifying microbes (polyphasic approach); Cell disruption and fractionation of organelles; Isolation and purification of membrane proteins; Various methods to study cell-cell and cell-virus fusion; Flow cytometry techniques; Confocal and Atomic Force Microscopy; Types of Biosafety cabinets	15

IV	**Experimental Models and instrumentation in Biology** Rodent and non-rodent models, worms as models for studying human-microbe interactions, Handling and maintenance of animals, Ventilated cages, Different routes of injections and collection of various biological components, Formulation of feed and design of experiments. Principle, instrumentation and environmental applications of Neutron Activation Analysis, X- Ray Fluorescence, X-Ray Diffraction, AAS, Hyphenated techniques-LC-MS/MS, GC-MS/MS, HPTLC-MS, ICP-MS. DLS-Dynamic light scattering techniques (Particle size analysis and Zeta potential), FTIR spectroscopy.	15

Suggested Readings:

1. Ausubel FW. Current Protocols in Molecular Biology. Wiley-Blackwell. 2011. Print
2. Burgess R. and Deutcher MP. Guide to Protein Purification. Academic Press, San Diego, USA. 2009. Print
3. Butler, M. Animal Cell Culture & Technology. 1st edition. Tailor & Francis Publishers (UK). 2004. Print
4. Freshney, R.I. Culture of Animal cells: A Manual of Basic Technique and specialized applications. 7th edition. Wiley-Blackwell. 2016. Print
5. Green M.R. and Sambrook J. Molecular Cloning: A Laboratory Manual. Vol. I, II, III. 4th edition. Cold spring harbor laboratory press. 2013. Print
6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
7. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
8. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
9. Instrumental methods of analysis (1988) 7th ed. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle (United States).
10. D.S. Goodsell 2013 Bionanotechnology: Lessons From Nature, John Wiley
11. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. Tata McGraw Hill, 1994.
12. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. Cengage India, 2015.

<table>
<tr><td colspan="4">Course Name: Research and Publication Ethics</td><td colspan="5">Course Code: SIAS BT 02 01 03 C 2002</td></tr>
<tr><td rowspan="2">Batch:
2022-2023</td><td rowspan="2">Programme:
Ph.D. Course work Biotechnology</td><td rowspan="2">Semester : I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td colspan="2">Contact Hrs. per Week: 02</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td colspan="2">Total Hrs.: 30</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 50
CIE: 20 Marks
TEE: 30 Marks</td><td colspan="6">Examination Duration: 2 Hrs.</td></tr>
<tr><td>Course Objective</td><td colspan="8">To get knowledge about the ethical issues in research and publication</td></tr>
<tr><td>Course Outcomes:</td><td colspan="8">After completion of this course, the students will be able:
1. To get information about ethics, intellectual honesty and scientific conduct during a research work
2. To know the concept of plagiarism and its significance in scientific writing and publication</td></tr>
</table>

COURSE SYLLABUS

NOTE: Total eight questions will be set from entire syllabus. Students need to attempt any five questions. Each question carries six marks.

Unit No.	Contents	Contact Hrs.
Theory		
I	**Philosophy and ethics** Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgement and reactions.	5
II	**Scientific conduct** Ethics with respect to science and research, intellectual honesty and research integrity, scientific misconducts: falsification, fabrication, and plagiarism, redundant publications, duplicate and overlapping publications, salami slicing, selective reporting and misrepresentation of data	5
III	**Publication ethics** Definition, introduction, and importance, best practices/standard settings, initiatives and guidelines: COPE, WAME etc. conflicts of interest, publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship, and contributorship, identification of publication misconduct, complaints, and appeals, predatory publishers and journals	5
Practice		
IV	**Open access publishing** Open access publications and initiatives: SHERPA/RoMEO online resources to check publisher copyrights and self-archiving policies, software tool to identify predatory publications developed by SPPO, journal finder/journal suggestion tools viz GANE; Elsevier journal finder, Springer journal suggester etc.	5

V	**Publication misconduct** **A. Group discussion** – subject specific ethical issues, FFP, authorship, conflict of interest, complaint and appeals: example and fraud from India and abroad. **B. Software tools** – Use of plagiarism software like turnitin, urkund, and other open source software tools	5
VI	**Databases and research matrices** A. Database – Indexing databases, citation databases: web of science, scopus, etc. B. Research matrix, impact factor of journal as per journal citation report, impact factor of journal as per journal citation report, SNIP, SJAR, IPP, Citescore, matrices, h-index, g-index, i10-index, almatrices	5

Suggested Readings:

1. Philosophy of Science, (2006), Bird, A., Routledge, ISBN 9781138705579.
2. A short history of ethics: A history of moral philosophy from the homeric age to the twentieth century (1967), MacIntyre, A., London, ISBN: 9780268161286.
3. Ethics in competitive research, do not get scooped; do not get plagiarized (2018), Chaddhah, P., ISBN-10: 9387480860
4. On being a scientist, a guide to responsible conduct in research (2009), National Academy of Science, National Academy of Engineering and Institute of Medicine, ISBN-10: 0309119707
5. Ethics in science education, research and governance (2019), Muralidhar K., Ghosh A., Singhvi A., Indian National Science Academy, ISBN: 9788193948217

Course Name: Omics Technologies					Course Code:SIAS BT 02 01 01 DCEC 4004	
Batch: 2022-2023	Programme: Ph.D. Course work Biotechnology	Semester : I	L 4	T 0	P 0	Credits 4	Contact Hrs. per Week: 04 Total Hrs.: 60

Total Evaluation Marks: 100 **CIE:** 40 Marks **TEE:** 60 Marks	**Examination Duration:** 3 Hrs.
Course Objectives	• To provide detailed understanding and applications of major Omics technologies such as genomics, transcriptomics, proteomics and metabolomics etc. • To provide knowledge about the data analysis of next generation sequencing.
Course Outcomes:	• Understanding of modern Omics technologies in the field of biotechnology. • Understanding of data analysis generated through next generation sequencing. • Better understanding of the applications of the Omics technologies in different industries.

COURSE SYLLABUS

NOTE: Total eight questions will be set from entire syllabus. Students need to attempt any five questions. Each question carries twelve marks.

Unit No.	Contents	Contact Hrs.
I	**Genomics:** Major genome sequencing projects, Next Generation Sequencing technologies, File formats, Basic pipeline for data analysis – quality check, adaptor trimming, Genome assembly, Genome annotation, Concepts of sequencing coverage and sequencing depth, phred score, N50, Introduction to different tools and algorithms, Data repositories and databases, Choice of sequencing platforms, Applications of genomics using case studies	15
II	**Transcriptomics:** Introduction to typical wet lab workflow, library preparation, and analysis pipeline, Choice of sequencing methods and tools for read mapping, assembly, identification of splicing variants and differential expression analysis, Tools available for pathways analysis, Gene Ontology, Hypergeometric enrichment analysis, Biogenesis, characteristics and analysis of small RNA like microRNAs and phasiRNAs, Analysis of long non-coding RNAs, Target prediction and functional prediction for small RNAs and lncRNAs, Applications of transcriptomics using case studies	15
III	**Proteomics:** Basic tools and techniques for protein separation and analysis, Mass spectrometry based proteomics: basic workflow and analysis pipeline, Quantitative proteomics and multiplexing, large scale analysis of protein modifications. Software packages and available tools for proteomics data analysis. Applications of mass spectrometry and proteomics using case studies.	15

IV	**Metabolomics**: Tools and techniques available for metabolomics analysis, targeted vs non-targeted metabolomics, experimental design and sample preparation, workflow, data analysis tools and repositories, data formats and key challenges, metabolite identification, metabolic fingerprinting, applications of metabolomics.	15

Suggested Readings:

1. Bioinformatics for omics data: methods and protocols (2011), Mayer, B., New York: Humana Press. ISBN 978-1617790270
2. Omics: Applications in Biomedical, Agricultural, and Environmental Sciences (2013), Barh D., Zambare V., Azevedo V. CRC Press. Taylor and Francis Group. ISBN 9781138074750
3. Applications of Advances Omics Technologies: from Genes to Metabolites (2014), Wilson and Wilsons. Elsevier. ISBN: 9780444626509
4. Genomics, Proteomics and Metabolomics in Nutraceuticals and Functional Foods (2015), Bagchi D., Swaroop A., Bagchi M. Wiley Blackwell. ISBN:9781118930427
5. Principles of Proteomics (2013), Twyman, R., Garland Science, ISBN: 978-0815344728

Course Name: Advances in Genetic Engineering					Course Code: SIAS BT 02 01 02 DCEC 4004		
Batch:	**Programme:**	**Semester : I**	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**
2022-2023	Ph.D. Course work Biotechnology		4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 40 Marks **TEE:** 60 Marks	**Examination Duration:** 3 Hrs.
Course Objectives	To provide basic and high throughput techniques in the areas of genomics and genetic engineering.
Course Outcomes:	• Understanding of various model organisms used in Biotechnology • Understand concept of genetic engineering including the techniques, applications and limitations • Demonstrate the ability of designing recombinant molecules and conducting experiments involving genetic manipulation

COURSE SYLLABUS

NOTE: Total eight questions will be set from entire syllabus. Students need to attempt any five questions. Each question carries twelve marks.

Unit No.	Contents	Contact Hrs.
I	Different model organisms used in biology and applied sciences research- *E. Coli*, *Saccharomyces crevices*, *Pichia pastoris*, Drosophila, *Arabidopsis*, Mice, Rat, etc; tools and techniques used in manipulation of their genome.	15
II	Genetic engineering and genome editing of agricultural crops – target traits such as yield, disease resistance, biotic and abiotic stress tolerance; phytoremediation using genetically modified plants; economic and environmental impact of genetically modified crops using real-time examples from already released varieties in different countries and current literature.	15
III	Genetic engineering of livestock including fish & poultry- target traits such as yield, disease resistance, biotic and abiotic stress tolerance; gene introgression through genome editing; bioremediation using genetically modified microbes & animals; transgenic animals and xeno-transplantation; economic and environmental impact using real time examples from current literature; ethical, moral and legal issues.	15
IV	Over expression of genes in heterologous systems; advantages and disadvantages of different heterologous systems for production of proteins, enzymes, monoclonal antibodies, vaccines; gene pharming and human pharmaceutical proteins.	15

Suggested Readings:

1. Genome editing in animals, Methods and protocols (2017) Hatada I. Springer Nature, ISBN: 978-1-4939-7128-2.
2. CRISPER- methods and protocols (2015) Lundgren M, Charpentier E and Fineran P. Springer Nature, ISBN: 978-1-4939-2687-9.
3. Mammalian and avian transgenesis new approaches (2006) Pease S and Lois C. Springer Nature, ISBN: 978-3-540-28489-5.
4. Principal of cloning 2nd edition, Jose C, Keith HS Campbell JG, Ian W, Robert L. Academic Press, ISBN 978-0-12-386541-0.
5. Transgenic Plants Methods and Protocol (2012) Dunwell JM, WettenAC.Springer Nature, ISBN 978-1-61779-558-9.
6. Transgenic plants: a production system for industrial and pharmaceutical proteins Meran RL, Owen and Jan P. 1st ed., Wiley, ISBN: 978-0471964438.
7. Transgenic plant technology for remediation of toxic metals and metalloids (2019) Majeti N, Vara P, Academic press, ISBN: 978-0-12-814389-6.
8. Genetically modified food: A critical review of their promise and problems (2016) Chen Z, Robert W and Han Z Food Science and Human Wellness, 5(3), 116-123.
9. Current perspective on genetically modified crops and detection methods (2017). Kamle M, Kumar P, Patra JK, Bajpai VK 3 Biotech. 7(3): 219,
10. The Impact of genetically modified crops in modern agriculture-A review (2017) Ruchir R. GM Crops Food. 8(4): 195–208.

Central University of Haryana
School of Interdisciplinary and Applied Sciences
Department of Biochemistry

Ph.D. Biochemistry
SCHEME AND CURRICULUM (2022-23)

Semester	Core/Elective	Course code	Title of the paper	Credit
I	Core	SIAS BC 02 01 01 C 4004	Research Methodology	4
	Core	SIAS BC 02 01 02 C 4004	Advanced Analytical Techniques	4
	Core	SIAS BC 02 01 03 C 2002	Research and Publication Ethics (RPE)	2
	Elective	SIAS BC 02 01 01 E 4004	Advanced Biochemistry	4
	Elective	SIAS BC 02 01 02 E 4004	Advanced Immunology	4
		Total		14

4/10/2022

26/10/22

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S.
Dean
School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh - 123031, Haryana, India

Course title: Research Methodology **Credit: 4**
Course code: SIAS BC 02 01 01 C 4004 **Lectures: 60**

Course objective: To provide knowledge about tools and techniques related with scientific communication, research methodology and biosafety in biological experiments.

Learning outcomes:

- Understanding the existence of scientific knowledge in ancient times
- Acquiring the skills of scientific reading, writing and presentations
- Appreciating the scientific ethics through case studies
- Understand the importance and level of biosafety at laboratory and industrial levels

Unit 1. Identification and defining of the Research Problem:
Familiarization of research areas; Review of literature using appropriate resources – reviews, research papers, books and patents; Use of tools for searching literature through electronic databases; Defining a research problem.

Unit 2. Experimental Approaches and Methodology
Experimental designs to address the research problem; Pros and cons of different experimental strategies; Finalization of experimental design; Tools and techniques to execute experiments; Means to validate and analyze data; Use of statistical tools for analyzing the significance and interpretation of the data; Measurement of central tendencies (Mean, Median, Mode); Measurement of variability (standard deviation, standard error of mean, range, mean deviation, coefficient of variation). Levels of significance; regression and correlation; t-test; Multiple range test; analysis of variance; chi square test.

Unit 3. Ethics and Safety in Biological Research
Guidelines for Biosafety and Bioethics; Institutional Biosafety Committee – Handling of Genetically modified organisms, Institutional Human and Animal Ethics Committee - compliance, concerns and approval; Safety practices and disposal of Bio-waste in the laboratory; Radioactivity and safety precautions; Handling and disposal of flammable and hazardous chemicals.

Unit 4. Presentation, Publication and Protection of Research Data
Development of skills for scientific writing and research presentation – Term paper, Research project, Research report, Thesis, Research article and Review; Organization of the research document in to different sections (Introduction, Methodology, Results, Discussion, and Summary and Conclusions, Bibliography); Use of electronic tools for bibliographic formatting and checking Plagiarism; Development of Oral presentation skills; Patents and Intellectual property rights.

Students are expected to undertake the following assignments, exercises for evaluation.

1. Identification and selection of the broad area of research
2. Review of literature, formulation of research plan and submission of term paper along with references
3. Oral presentation of research plan and experimental design

Evaluation will be based on term paper and oral presentation

Suggested readings

1. Communicate Science Papers, Presentations, and Posters Effectively (2015) Patience GS, Boffito DC, Patience P, Academic Press, ISBN: 978-0128015001.
2. Research Methodology: Methods And Techniques (2019) 4th ed., Kothari CR and Garg G, New Age International Publishers, ISBN: 978-9386649225.
3. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (2014) 4th ed., Matthews JR and Matthews RW, Cambridge University Press ISBN: 978-1107691933.
4. Doing Science: Design, Analysis, and Communication of Scientific Research. (2001) Valiela I, Oxford: Oxford University Press, ISBN 10:019538573X.
5. Beauchamp T.L., Walters L., Kahn J.P. & Anna C. Contemporary issues in Bioethics. Wardsworth Publishers. Co. 2013. Print
6. Cross C.L. and Wayne W.D. Biostatistics: Basic Concepts and Methodology for the Health Sciences. 10th edition, Wiley. 2014. Print
7. Davis, G.B. and Straub D.W. Writing the doctoral dissertation. 3rd edition. Barron's Educational series. 2012. Print
8. Deepa Goel. IPR, Biosafety and Bioethics.1st edition. Pearson Education. 2013. Print
9. Krishnaswamy, K.N., Mathiranjan M., and Sivakumar, A.I. Management Research Methodology; Integration of Principles, Methods and Techniques. Pearson Education. 2011. Print
10. Montgomery, Douglas C. Design and Analysis of Experiments. 8th edition. Wiley. 2013. Print
11. Rao S and Richard J. Introduction to Biostatistics and Research Methods. 5th edition. Prentice Hall India Learning Private Limited. 2012. Print
12. IPR, Biosafety and Bioethics (2013) Parashar S, Goel D, Pearson Publishing India, ISBN: 9788131774700.
13. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) Nambisan P, Academic Press, ISBN: 9780128092316.
14. http://dbtindia.gov.in/guidelines-biosafety

Course title: Advanced Analytical Techniques **Credit: 4**
Course code: SIAS BC 02 01 02 C 4004 **Lectures: 60**

Course objective: To provide an advanced understanding of the core principles of various techniques used in biological experiments.

Learning outcomes:

- Demonstrate principles of various basic and advanced techniques used in biological experiments
- Critically analyze and interpret the results obtained from biological experiments

Unit 1. Recombinant DNA techniques and Genomics

Use of Restriction and modification enzymes in cloning; Plasmid vector; Transformation and Plasmid isolation; PCR; DNA sequencing methods (Sanger's chain termination method, and automated DNA sequencing); Next generation sequencing (NGS); Global expression profiling; Whole genome analysis of mRNA and protein expression; Real time PCR and Microarrays and their applications

Unit 2. Proteomics and Nanotechnology

UV and fluorescence spectroscopy; Circular Dichroism; Mass spectrometry - Principles and their applications; Protein separation techniques and instrumentation (Gel filtration, Ion exchange and Affinity chromatography, 1D and 2D Polyacrylamide gel electrophoresis); Immunochemical detection of proteins.; Introduction and overview of Metabolomics; Nanotechnology and its Applications in pharmaceutical Industry, Agriculture, Food Industry, Manufacturing Industry, and Renewable Energy Sector.

Unit 3. Microbial and Cellular Techniques

Microscopic techniques; Microbial growth and kinetics (synchronous culture, continuous and batch and fed-batch cultures, chemostat and turbidostat); Methods for identifying microbes (polyphasic approach); Cell disruption and fractionation of organelles; Isolation and purification of membrane proteins; Various methods to study cell-cell and cell-virus fusion; Flow cytometry techniques; Confocal and Atomic Force Microscopy; Types of Biosafety cabinets

Unit 4. Experimental Models and instrumentation in Biology

Rodent and non-rodent models, worms as models for studying human-microbe interactions, Handling and maintenance of animals, Ventilated cages, Different routes of injections and collection of various biological components, Formulation of feed and design of experiments. Principle, instrumentation and environmental applications of Neutron Activation Analysis, X-Ray Fluorescence, X-Ray Diffraction, AAS, Hyphenated techniques-LC-MS/MS, GC-MS/MS, HPTLC-MS, ICP-MS.

Suggested readings

1. Ausubel FW. Current Protocols in Molecular Biology. Wiley-Blackwell. 2011. Print
2. Burgess R. and Deutcher MP. Guide to Protein Purification. Academic Press, San Diego, USA. 2009. Print
3. Butler, M. Animal Cell Culture & Technology. 1st edition. Tailor & Francis Publishers (UK). 2004. Print

4. Freshney, R.I. Culture of Animal cells: A Manual of Basic Technique and specialized applications. 7th edition. Wiley-Blackwell. 2016. Print
5. Green M.R. and Sambrook J. Molecular Cloning: A Laboratory Manual. Vol. I, II, III. 4th edition. Cold spring harbor laboratory press. 2013. Print
6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
7. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
8. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
9. Instrumental methods of analysis (1988) 7th ed. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle (United States).
10. D.S. Goodsell 2013 Bionanotechnology: Lessons From Nature, John Wiley
11. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. Tata McGraw Hill, 1994.
12. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. Cengage India, 2015.

Course title: Research and Publication Ethics **Credit: 2**

Course code: SIAS BC 02 01 03 C 2002 **Lectures: 30**

Course objective: To learn philosophy of science, research misconduct and integrity, publication plagiarism and ethics.

Learning Outcomes:

- Learn to identify the FFP in research and ethics of publication.
- Hands on session help to find research misconduct, predatory publication, publications metrics and plagiarism.
- To learn database citation and indexing of publication.

Part A: THEORY

Unit1 Philosophy & ethics

Introduction of Philosophy; definition, nature and scope, concept, branches. Ethics; definition, moral philosophy, nature of moral judgments and reactions.

Unit II Scientific conduct

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific Misconduct; falsification, fabrication and Plagiarism (FFP), Redundant publications; duplicate and overlapping publications, salami slicing.

Unit III Publication ethics

Publication ethics; definition, introduction and importance. Best Practices/ standards setting initiatives and guidelines: COPE, WAME etc., Conflict of Interest, Publication misconduct: definition, concept, problems lead to unethical behavior and vice-versa, types, Violation of publication ethics, authorship and contributor-ship, Identification of publication misconduct, complaint and appeals, Predatory publications and journals.

Part B: PRACTICE

Unit IV Open access publishing

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-achieving policies, Software tools to identify predatory publications developed by SPPU, Journal finder Journal suggestion tools vis. JANE, Elsevier journal finder, Springer journal suggested etc.

Unit V Publication misconduct

Group discussion; Subject specific ethical issues, FFP, Authorship, Conflict of interest, Complaint and appeals; example and fraud from India and abroad. Software tools; turnitin, urkund and other open source plagiarism tools.

Unit VI Database and research metrics

Database: Indexing citation database; Web of Science and Scopus etc., Research metrics; Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score, Metrics; h index, g index, i10, altmetrics.

Suggested readings

1. Bird A. Philosophy of science. Routledge. 2006. ISBN 9781138705579.
2. MacIntyre A. A short history of ethics: A history of moral philosophy from the homeric age to the twentieth century. London. 1967. ISBN: 9780268161286.
3. Chaddhah P. Ethics in competitive research, do not get scooped; do not get plagiarized. 2018. ISBN-10: 9387480860
4. On being a scientist, a guide to responsible conduct in research. National Academy of Science, National Academy of Engineering and Institute of Medicine. 2009. ISBN-10: 0309119707
5. Muralidhar K. Ghosh A. Singhvi A. Ethics in science education, research and governance. Indian National Science Academy. 2019. ISBN: 9788193948217

Course title: Advanced Biochemistry **Credit: 4**

Course code: SIAS BC 02 01 01 E 4004 **Hour: 60 hour**

Course objective: To understand the biochemistry of biomolecules and their role in biological system.

Learning Outcome

Upon completion of this course, the student will be able to:

- Evaluate the structure of carbohydrates, Lipids and their functions
- Understand the various orders of protein structure, classification, properties and organization of nucleic acids with their biological functions
- Understand the basic metabolic pathways of the carbohydrates, lipids, amino acids and Nucleic acid metabolism
- Acquire insight into functions of enzymes and mechanism of enzyme catalysis

Unit I:

Carbohydrates-Structure, reactions and functions of monosaccharides, disaccharides, polysaccharides and complex carbohydrates, amino sugars, proteoglycans and glycoproteins. Lipids - Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, bile acids and lipoproteins.

Unit II

Amino acids- Classification of amino acids and properties, isoelectric pH, zwitterions, Peptide bond. Structure of protein- primary, secondary, tertiary and quaternary structures, Ramachandran plot. Chemistry of purine & pyrimidine, nucleosides, nucleotides, Structure and properties of DNA, Types of DNA & RNA, structure and functions of mRNA, tRNA, rRNA.

Unit III:

Glycolysis, TCA Cycle, Glyoxylate cycle, Pentose phosphate pathway of glucose oxidation, gluconeogenesis and regulation. Fatty acid oxidation and synthesis. Overview of amino acid degradation, transamination and the role of pyridoxal phosphate, oxidative deamination, urea cycle. De novo and salvage synthesis pathways of nucleotides.

Unit IV

Enzymes- general characteristics, Classification and Nomenclature, Coenzymes and Cofactors, activation energy and transition state theory, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis, Initial velocity and substrate concentration relationship, derivation of Michaelis- Menten equation, Significance of Km, Vmax, Kcat, and Kcat/Km, Lineweaver-Burk plot, Enzyme inhibition.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Stryer L, Berg JM, Tymoczko JL. Gatto GJ. (2015) Biochemistry, 8th Edition. W. H. Freeman
3. Grisham CM, Garrett RH. (2012) Biochemistry. 6th Edition. Brooks Cole
4. Voet DV, Voet JG. (2011) Biochemistry, Wiley
5. Palmer T. (2004) Enzymes. East – West Press Pvt. Ltd., Delhi.

Course title: Advanced Immunology **Credit: 4**

Course code: SIAS BC 02 01 02 E 4004 **Hour: 60 hour**

Course objective:

To understand the cellular components of the immune system and their corresponding immune responses in normal and deregulated systems

Learning Outcome

- Review basic principles of Immunology
- Understanding molecular mechanism of dysregulation and disorders associated when immune system fails
- Understand mechanisms by which the immune system and cells interact to affect nervous system and tumor growth
- Explore therapies and various strategies being developed and employed to manipulate cell-cell interactions in immune-pathological situations.

Unit-I: Introductory immunology: molecules and mediators

Host Defense systems; Hematopoiesis, cells of the immune system; Components and connections between Innate and Adaptive Immunity; Immunoglobulins (Ig) and their organization; Complement system; Structure Function and Organization of MHC.

Unit-II: Breaking tolerance: autoimmunity & dysregulation

Deficiencies/Defects of Immune Cells; Central & Peripheral Tolerance; Mucosal Immunity & Immunopathology; Regulation of Immunity & the Microbiome; Epigenetics & Modulation of Immunity; Hypersensitivity; Inflammation and autoinflammation; T cell mediated autoimmune diseases; Antibody-mediated autoimmune diseases; Infectious Diseases; Transplantation; Immune Regulation in Pregnancy.

Unit-III: System immunology: Stem cell/cancer and neuro immunology

Stem Cell and Cancer Immunology; Tumor Origination and Progression; Tumor Antigens; Immunosurveillance; Immune Cell Trafficking; Immune response during Metastasis and Invasion Neuroimmunology Blood-Brain Barrier; Brain tumours; Acute, Persistent and latent neurotropic viral infections; Bacterial and parasitic infections; Myasthenia Gravis and Guillain-Barre; Alzheimer's disease; Transmissible spongiform encephalopathies.

Unit-IV: Applications and immunotherapy

Cytokines and their Therapeutic uses; Antibody and Vaccine development strategies (Recombinant, Combined and polyvalent vaccines); DC Vaccines; Methods to evaluate immune responses; Recent techniques in Immuno-disorder diagnostics; Current topics in Immunotherapy: Success and failures.

Suggested Reading

1. Punt J, Stranford S, Jones P and Owen JA, W.H Freeman and Company. Kuby Immunology. 8th ed. 2018. ISBN: 978-1319114701.
2. Murphy KM and Beaver C, WW Norton and Company. Janeway's Immunobiology 9th ed. 2017. ISBN: 978-0815345510.
3. Delvis PJ, Martin SJ, Burton DR and Roitt, IM. Roitt's Essential Immunology. 13th ed., Wiley-Blackwell. 2017. ISBN: 978-1118415771.
4. Cancer Immunotherapy (Second edition), edited by Prendergast and Jaffee
5. Robert Weinberg. The Biology of Cancer (2nd edition). Garland Science

Annexure-XIX

CBCS Based Curriculum and Syllabus

Ph.D. Environmental Sciences

Course Work (w.e.f. 2022)

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S.
Dean
School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh 123031, Haryana, India

Department of Environmental Studies

Central University of Haryana

(Established under Central Universities Act, 2009)

(NAAC Accredited 'A' Grade)

Central University of Haryana

Department of Environmental Studies

Structure of Programme (Ph.D. Environmental Sciences)

SEMESTER – I						Total Credits: 14
Sr. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	SIAS EVS 02 01 01 C 4004	Research Methodology	4	0	0	4
2.	SIAS EVS 02 01 02 C 4004	Advanced Analytical Techniques	4	0	0	4
3.	SIAS EVS 02 01 03 C 2002	Research and Publication Ethics	2	0	0	2
Choose any one of the following two DCEC courses:						
4.	SIAS EVS 02 01 04 DCEC 4004	Current Environmental Issues and Remediation	4	0	0	4
5.	SIAS EVS 02 01 05 DCEC 4004	Statistics in Environmental Sciences	4	0	0	4

Prof. Neelam Sangwan
F.N.A., F.N.A.Sc., F.N.A.A.S.
Dean
School of Interdisciplinary & Applied Sciences
Central University of Haryana
Mahendergarh - 123031, Haryana

Course Type : **Core**

Course Name : **Research Methodology**

Course Code : **SIAS EVS 02 01 01 C 4004**

Credit : **4**

Course Objective and Learning Outcomes:

To provide knowledge about tools and techniques related with scientific communication, research methodology and biosafety in biological experiments.

Learning outcomes:

- Understanding the existence of scientific knowledge in ancient times
- Acquiring the skills of scientific reading, writing and presentations
- Appreciating the scientific ethics through case studies
- Understand the importance and level of biosafety at laboratory and industrial levels

UNIT 1: IDENTIFICATION AND DEFINING OF THE RESEARCH PROBLEM

Familiarization of research areas; Review of literature using appropriate resources – reviews, research papers, books and patents; Use of tools for searching literature through electronic databases; Defining a research problem.

UNIT 2: EXPERIMENTAL APPROACHES AND METHODOLOGY

Experimental designs to address the research problem; Pros and cons of different experimental strategies; Finalization of experimental design; Tools and techniques to execute experiments; Means to validate and analyze data; Use of statistical tools for analyzing the significance and interpretation of the data; Measurement of central tendencies (Mean, Median, Mode); Measurement of variability (standard deviation, standard error of mean, range, mean deviation, coefficient of variation). Levels of significance; regression and correlation; t-test; multiple range test; analysis of variance; chi square test.

UNIT 3: ETHICS AND SAFETY IN BIOLOGICAL RESEARCH

Guidelines for Biosafety and Bioethics; Institutional Biosafety Committee – Handling of Genetically modified organisms, Institutional Human and Animal Ethics Committee - compliance, concerns and approval; Safety practices and disposal of Bio-waste in the laboratory; Radioactivity and safety precautions; Handling and disposal of flammable and hazardous chemicals.

UNIT 4: PRESENTATION, PUBLICATION AND PROTECTION OF RESEARCH DATA

Development of skills for scientific writing and research presentation – Term paper, Research project, Research report, Thesis, Research article and Review; Organization of the research document in to different sections (Introduction, Methodology, Results, Discussion, and Summary and Conclusions, Bibliography); Use of electronic tools for bibliographic formatting and checking Plagiarism; Development of Oral presentation skills; Patents and Intellectual property rights.

Students are expected to undertake the following assignments, exercises for evaluation.

1. Identification and selection of the broad area of research.
2. Review of literature, formulation of research plan and submission of term paper along with references
3. Oral presentation of research plan and experimental design.

Evaluation will be based on term paper and oral presentation

Suggested Readings

1. Communicate Science Papers, Presentations, and Posters Effectively (2015) Patience GS, Boffito DC, Patience P, Academic Press, ISBN: 978-0128015001.
2. Research Methodology: Methods And Techniques (2019) 4th ed., Kothari CR and Garg G, New Age International Publishers, ISBN: 978-9386649225.
3. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (2014) 4th ed., Matthews JR and Matthews RW, Cambridge University Press ISBN: 978-1107691933.
4. Doing Science: Design, Analysis, and Communication of Scientific Research. (2001) Valiela I, Oxford: Oxford University Press, ISBN 10:019538573X.
5. Beauchamp T.L., Walters L., Kahn J.P. & Anna C. Contemporary issues in Bioethics. Wardsworth Publishers. Co. 2013. Print
6. Cross C.L. and Wayne W.D. Biostatistics: Basic Concepts and Methodology for the Health Sciences. 10th edition, Wiley. 2014. Print
7. Davis, G.B. and Straub D.W. Writing the doctoral dissertation. 3rd edition. Barron's Educational series. 2012. Print
8. Deepa Goel. IPR, Biosafety and Bioethics.1st edition. Pearson Education. 2013. Print
9. Krishnaswamy, K.N., Mathiranjan M., and Sivakumar, A.I. Management Research Methodology; Integration of Principles, Methods and Techniques. Pearson Education. 2011. Print
10. Montgomery, Douglas C. Design and Analysis of Experiments. 8th edition. Wiley. 2013. Print
11. Rao S and Richard J. Introduction to Biostatistics and Research Methods. 5th edition. Prentice Hall India Learning Private Limited. 2012. Print
12. IPR, Biosafety and Bioethics (2013) Parashar S, Goel D, Pearson Publishing India, ISBN: 9788131774700.
13. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) Nambisan P, Academic Press, ISBN: 9780128092316.
14. http://dbtindia.gov.in/guidelines-biosafety

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Course Type : **Core**

Course Name : **Advanced Analytical Techniques**

Course Code : **SIAS EVS 02 01 02 C 4004**

Credit : **4**

Course Objective and Learning Outcomes:

Course Objectives: To provide an advanced understanding of the core principles of various techniques used in biological experiments

Learning outcomes:

- Demonstrate principles of various basic and advanced techniques used in biological experiments
- Critically analyze and interpret the results obtained from biological experiments

UNIT 1: RECOMBINANT DNA TECHNIQUES AND GENOMICS

Use of Restriction and modification enzymes in cloning; Plasmid vector; Transformation and Plasmid isolation; PCR; DNA sequencing methods (Sanger's chain termination method, and automated DNA sequencing); Next generation sequencing (NGS); Global expression profiling; Whole genome analysis of mRNA and protein expression; Real time PCR and Microarrays and their applications

UNIT 2: PROTEOMICS AND NANOTECHNOLOGY

UV and fluorescence spectroscopy; Circular Dichroism; Mass spectrometry - Principles and their applications; Protein separation techniques and instrumentation (Gel filtration, Ion exchange and Affinity chromatography, 1D and 2D Polyacrylamide gel electrophoresis); Immunochemical detection of proteins.; Introduction and overview of Metabolomics; Nanotechnology and its Applications in pharmaceutical Industry, Agriculture, Food Industry, Manufacturing Industry, and Renewable Energy Sector.

UNIT 3: MICROBIAL AND CELLULAR TECHNIQUES

Microscopic techniques; Microbial growth and kinetics (synchronous culture, continuous and batch and fed-batch cultures, chemostat and turbidostat); Methods for identifying microbes (polyphasic approach); Cell disruption and fractionation of organelles; Isolation and purification of membrane proteins; Various methods to study cell-cell and cell-virus fusion; Flow cytometry techniques; Confocal and Atomic Force Microscopy; Types of Biosafety cabinets

UNIT 4: EXPERIMENTAL MODELS AND INSTRUMENTATION IN BIOLOGY

Rodent and non-rodent models, worms as models for studying human-microbe interactions, Handling and maintenance of animals, Ventilated cages, Different routes of injections and collection of various biological components, Formulation of feed and design of experiments. Principle, instrumentation and environmental applications of Neutron Activation Analysis, X-

Ray Fluorescence, X-Ray Diffraction, AAS, Hyphenated techniques-LC-MS/MS, GC-MS/MS, HPTLC-MS, ICP-MS.

Suggested readings

1. Ausubel FW. Current Protocols in Molecular Biology. Wiley-Blackwell. 2011. Print
2. Burgess R. and Deutcher MP. Guide to Protein Purification. Academic Press, San Diego, USA. 2009. Print
3. Butler, M. Animal Cell Culture & Technology. 1st edition. Tailor & Francis Publishers (UK). 2004. Print
4. Freshney, R.I. Culture of Animal cells: A Manual of Basic Technique and specialized applications. 7th edition. Wiley-Blackwell. 2016. Print
5. Green M.R. and Sambrook J. Molecular Cloning: A Laboratory Manual. Vol. I, II, III. 4th edition. Cold spring harbor laboratory press. 2013. Print
6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
7. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
8. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
9. Instrumental methods of analysis (1988) 7th ed. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle (United States).
10. D.S. Goodsell 2013 Bionanotechnology: Lessons From Nature, John Wiley
11. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. Tata McGraw Hill, 1994.
12. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. Cengage India, 2015.

Course Type : **Core**

Course Name : **Research and Publication Ethics**

Course Code : **SIAS EVS 02 01 05 DCEC 4004**

Credit : **2**

Theory

RPE 01: Philosophy and Ethics (3 hrs.)

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgement and reactions

RPE 02: Scientific Conduct (5 hrs.)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs.)

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidance: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour
1. and vice versa, types
5. Violation of publication ethics, authorship and contributor ship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practice

RPE 04: Open Access Publishing (4 hrs.)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE 05: Publication Misconduct (4 hrs.)

A. Group Discussion (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest

3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

1. Use of plagiarism software like Turnitin, Urkund and other open-source software tools

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs,)

1. Indexing databases Research Metrics
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score
2. Metrics: h index, g index, i10 index, almetrics

Suggested Readings

1. Bird, A. (2006). Philosophy of Science. Routledge
2. MacIntyre, Alasdair (1967) A Short History of Ethics. London
3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition. National Academics Press.
5. Resnik, D. B. (2011). What is ethics in research and why is it important. National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm.
6. Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489 (7415), 179-179. https://doi.org/10.1038/489179a
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf.

Course Type : **Elective**

Course Name : **Current Environmental Issues and Remediation**

Course Code : **SIAS EVS 02 01 03 C 2002**

Credit : **4**

Course Objective and Learning Outcomes:

To provide knowledge about current environmental issues at global and national levels and their remediation techniques. This paper also aims to provide understanding the various current environmental issues, acquiring the skills of remediation using biomass and plants, acquire knowledge of phycoremediation for treatment of wastes and understanding the production and handling methods of hydrogen: a non-polluting future fuel.

UNIT 1: GLOBAL AND NATIONAL ENVIRONMENTAL ISSUES

Climate Change, Ozone layer depletion, Biodiversity Conservation, Industrial Ecology, National Environmental Policy, Ecomark Scheme, ISO Environment Series, Bioprospecting, Biopiracy, Circular Economy

UNIT 2: BIOREMEDIATION OF POLLUTED SITES

Role of microbes & plants; microbial degradation of environmental pollutants; Bioremediation practices & technologies, biosensors, Biosorption; Microbial biosorption; Mechanisms of biosorption & bioaccumulation; Chemical and physical aspects of sorption process.

UNIT 3: PHYTOREMEDIATION AND PHYCOREMEDIATION

Mechanisms & techniques of Phytoremediation, Applications of Phycoremediation, Phytotechnology applications– Culturing & preservation techniques, Zero waste Biorefinery.

UNIT 4: REMEDIATION

Photobiological and fermentative hydrogen production– basic metabolic process & research needs, Bioindicators, bioaccumulators and moderators of pollution, Principles of Green Chemistry, Nanoparticles synthesis and their applications, Biopolymers; Accessory pigments & their functions; Cyanobacterial biofertilizers; Cryptobiotic crusts – their environmental significance.

Suggested Readings

1. D. Kemp; Global Environmental Issues: A Climatological Approach. 2ND Edition. 1994. ISBN 9780415103107
2. Frances Harris; Global Environmental Issues (2005), ISBN: 978-0-470-09395-5, Wiley
3. Vimal Chandra Pandey, Vijai Singh; Bioremediation of Pollutants from Genetic Engineering to Genome Engineering (2020), ISBN: 9780128190258

4. Surajit Das, Hirak Dash; Microbial Biodegradation and Bioremediation: Techniques and Case Studies for Environmental Pollution 2nd Edition (2021), ISBN: 9780323854559
5. Ajay Singh, Owen P. Ward; Applied Bioremediation and Phytoremediation (2013) 2004th Edition, Springer.
6. Bikram Basak, Apurba Dey; Bioremediation Approaches for Recalcitrant Pollutants: Potentiality, Success and Limitation (2016)
7. Inamuddin, Mohd Imran Ahamed, Eric Lichtfouse, Abdullah M. Asiri; Methods for Bioremediation of Water and Wastewater Pollution: Environmental Chemistry for a Sustainable World (2020), Springer Nature Switzerland.
8. Abid A. Ansari, Sarvajeet Singh Gill, Ritu Gill, Guy R. Lanza; Phytoremediation Management of Environmental Contaminants, Volume ISBN978-3-319-34634-2.
9. Junaid Ahmad Malik; Handbook of Research on Microbial Remediation and Microbial Biotechnology for Sustainable Soil (Hardcover) (2021) Engineering Science Reference, ISBN: 9781799870623

Course Type	**: Elective**
Course Name	**: Statistics in Environmental Sciences**
Course Code	**: SIAS EVS 02 01 04 DCEC 4004**
Credit	**: 4**

Course Objective and Learning Outcomes:

Prepare students to apply basic statistical concepts in their research/professional activities, to improve the causal understanding and reasoning of statistical results and building experience in data visualization. Students will be benefitted in shorting and managing of environmental data. It will be helpful in the assessment and understanding of the environmental components. Helpful in prediction, sorting and mathematical modelling to provide solutions of the environment problems

UNIT-I: INTRODUCTION OF STATISTICS

Importance of statistics in Environmental Sciences, Attributes and Variables: types of variables, scales of measurement, collection and processing of data, Concept of frequency distribution, Sample and Population, Sampling Distribution, Sampling Types, Diagrammatic and Graphical representation of Data – Line diagram, Pie diagram, Bar diagram, histogram, frequency polygon, frequency curve and cumulative frequency curve.

UNIT-II: DESCRIPTIVE STATISTICS

Measures of Central Tendency - mean, median, mode, geometric mean and harmonic mean. Measures of Dispersion - range, mean deviation, standard deviation, quartile deviation coefficient of variation, Skewness and Kurtosis.

UNIT-III: PROBABILITY THEORY

Basic concepts of probability theory: Mutually Exclusive Events and Independent Events, Probability and theorems of probability, Conditional Probability, Discrete and Continuous Random Variables, Theoretical Probability Distributions - Binomial, Poisson, Normal and Log-Normal distributions,

UNIT-IV: RELATIONSHIP AND TESTING OF PARAMETERS

Correlation analysis, types of correlation, methods of correlation analysis, degree of correlation and significance test of correlation coefficient, Regression analysis, types of regression analysis, and significance test of regression coefficient, Standard Error and Significance Levels and Confidence Limits, Hypothesis Testing: Null Hypothesis, Type I and Type II errors, t-test, Chi-square test, F-test, , ANOVA: one-way and two-way, Experimental design, Concept, Principles and types of Experimental Design, Error Control

Suggested readings

1. Gupta S C (2019). Fundamental of Statistics, Himalayan Publisher.
2. Gupta S C, Kapoor V K (2020). Fundamental of Mathematical Statistical, Sultan Chand &
3. Sons Publishers, New Delhi, ISBN: 9789351611738, 9351611736
4. Hogg R V, Craig A T (2018). Introduction to mathematical statistics, Macmillan Pub. Co. Inc.
5. McClave J (2018). Sincich Statistics, Pearson Publisher.
6. Mohanty P K, Patel S K (2015). Basic statistics, New Delhi: Scientific Publishers
7. Murray R S, Larry S (2017). Schaum's Outline of Statistics, McGraw-Hill Education (ISE Editions).
8. Sheldon M R (2017). Introductory to Statistics, Academic Press, Elsevier.
9. Willard C A (2020) Statistical Methods: An Introduction to Basic Statistical Concepts and Analysis. United Kingdom: Taylor & Francis

Learning Outcome-based Curriculum Framework for M. Pharm (Pharmacology)

[NEP-2020]

2022-23

6/10/2022

06/10/2022

Department of Pharmaceutical Sciences

CENTRAL UNIVERSITY OF HARYANA

Jant-Pali, Mahendergarh, Haryana-123031, India

Table of contents

1. Background

1.1. Introduction to Department of Pharmaceutical Sciences

The Department of Pharmaceutical Sciences was established in 2020 as a flagship department of Central University of Haryana to provide quality education and training to pharmacy graduates to become highly skilled and caring healthcare professionals and create new knowledge through excellence in basic and translational pharmaceutical research. The department is currently offering **M. Pharm. (Pharmacology)** course for Pharmacy graduates duly approved by Pharmacy Council of India (PCI), New Delhi. The department has engaged experienced, vibrant and well-qualified faculties involved in both teaching and research work. The faculty members have published a substantial number of research papers in journals of national and International repute.

The department is focussed to train the students/scholars in emerging fields of pharmacy catering to pharmaceutical industry and R&D. We have a vision to train and nurture the students towards fundamental & advanced research in pharmacy leading to technological innovation and entrepreneurship. Having collaborations with prominent national and international institutions in future, the department aims to carry out collaborative research in thrust areas of health and medicines.

The department also plans to initiate the research in the field of Natural products in future with focus to identify novel targets and explore their pharmacological benefits in the treatment of various ailments/disorders. The Department of Pharmaceutical Sciences aims at identifying and characterising both new biologically active natural products and their semisynthetic derivatives and at understanding their interactions with human targets on a molecular level using in silico, in vitro, and in vivo models. Based on this knowledge, new lead compounds and disease-relevant targets will be investigated and novel delivery systems for pharmaceutical active ingredients will be developed. Main areas of research include:

a) Ethnopharmacology of Indigenous medicinal plants
b) Development of Nanoformulations of selected Natural Products and their evaluation
c) Standardization and characterization of Ayurvedic/Homeopathic/Unani herbal formulations
d) Neuropharmacology
e) Pharmacovigilance

M. Pharm. (Pharmacology) provides unprecedented opportunities in Pharmaceutical industries focussed on preclinical and clinical research & development, regulatory aspects, Medical writing, and Intellectual property rights (IPR).

1.2.Vision of the Department

- To contribute in the innovation and leadership of healthcare system through superior dissemination of Pharmaceutical knowledge.

1.3.Mission of the Department

- To nurture the young minds towards fundamental & advanced Pharmaceutical research that contribute to the technological innovation and entrepreneurship.
- To provide an integrated and rigorous coursework to fulfill the needs of Pharmaceutical industry and society.
- To create a center of excellence by building collaborations with industry and research institutions.

2. Program Educational Objectives (PEOs)

- **PEO-1:** The Postgraduate students will have a comprehensive knowledge of designing, conducting, analysis, reporting and documentation of the preclinical and clinical research.
- **PEO-2:** The Postgraduate students will integrate basic Pharmacology knowledge and skills with healthcare requirements of the society.
- **PEO-3:** The Postgraduate students will become competent by applying their technical, and leadership skills in pharmaceutical research.

3. Program Outcomes

PO-1: Basic and applied knowledge: Interdisciplinary knowledge to find solution for the complex biological problems

PO-2: Problem analysis: Ability to analyse society related/ applied research problem, design and execute experiments to find relevant solutions

PO-3: Advanced Usage of Technology: Apply advanced instrumentation tools, online resources with an understanding of the troubleshooting and limitations

PO-4: Ethics: Commitment towards professional ethics and responsibilities as a social endeavour to bring harmony with nature

PO-5: Lifelong learning: Scientific skills for industrial applications and entrepreneurship

4. Programme Specific Outcomes (PSOs)

- **PSO-1:** To provide the efficient knowledge of fundamental concepts of Pharmacology.
- **PSO-2:** Analysis and problem solving capability in the field of pharmaceutical sciences.
- **PSO-3:** To develop the professional skills in the area of pharmacological sciences to meet global demand and look for opportunities in Pharmaceutical industries.
- **PSO-4:** To give exposure of latest tools and techniques utilized in preclinical and clinical pharmacology
- **PSO-5:** To give an immersive professional experience to adapt in a globe of constantly developing trend.
- **PSO-6:** To inculcate professional ethics, communication skills, and leadership skills.
- **PSO-7:** To develop students' ability to provide advice on the utilization of medicines and the promotion of drug safety.

5. Postgraduate Attributes

- Pharmacy Knowledge
- Problem analysis
- Design and conduct the investigations of complex problems
- Modern tool usage
- Pharmacist and Society
- Leadership skills
- Communication skills
- Environment and sustainability
- Life-long learning
- Research ethics

6. Structure of Course (M. Pharm. Pharmacology)

Semester-I

Core Course	Course Code	Course	Credit Points	L	T	P	S
1	MPL 101T	Modern Pharmaceutical Analytical Techniques	4	4	0	0	0
2	MPL 102T	Advanced Pharmacology-I	4	4	0	0	0
3	MPL 103T	Pharmacological and Toxicological Screening Methods-I	4	4	0	0	0
4	MPL 104T	Cellular and Molecular Pharmacology	4	4	0	0	0
5	MPL 105P	Pharmacology Practical-I	6	0	0	12	0
6	MPL 106S	Seminar/Assignment	4	0	0	0	7

Semester-II

Core Course	Course Code	Course	Credit Points	L	T	P	S
7	MPL 201T	Advanced Pharmacology II	4	4	0	0	0
8	MPL 202T	Pharmacological and Toxicological Screening Methods-II	4	4	0	0	0
9	MPL 203T	Principles of Drug Discovery	4	4	0	0	0
10	MPL 204T	Clinical Research and Pharmacovigilance	4	4	0	0	0
11	MPL 205P	Pharmacology Practical II	6	0	0	12	0
12	MPL 206S	Seminar/Assignment	4	0	0	0	7

Semester-III				
Core Course	**Course Code**	**Course**	**Credit Hours**	**Credit Points**
13	MPL 301T	Research Methodology and Biostatistics	4	4
14	MPL 302	Journal club	1	1
15	MPL 303	Discussion / Presentation (Proposal Presentation)	2	2
16	MPL 304	Research Work	28	14

Semester-IV

Core Course	Course Code	Course	Credit Hours	Credit Points
17	MPL 401	Journal club	1	1
18	MPL 402	Research Work	31	16
19	MPL 403	Discussion/Final Presentation	4	4

7. Learning Outcome Index (Core Courses)

PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7
CC-1		✓	✓	✓	✓		
CC-2	✓	✓	✓		✓	✓	✓
CC-3	✓	✓	✓	✓	✓	✓	✓
CC-4	✓	✓	✓	✓	✓		✓
CC-5	✓	✓	✓	✓	✓	✓	
CC-6	✓				✓	✓	
CC-7	✓	✓	✓		✓	✓	✓
CC-8	✓	✓	✓	✓	✓		✓
CC-9		✓	✓	✓	✓		✓
CC-10		✓	✓	✓	✓	✓	✓
CC-11	✓	✓	✓	✓	✓	✓	
CC-12	✓				✓	✓	
CC-13		✓	✓	✓	✓		
CC-14		✓		✓	✓	✓	✓
CC-15		✓	✓		✓	✓	✓
CC-16		✓	✓	✓	✓	✓	✓
CC-17		✓		✓	✓	✓	✓
CC-18		✓	✓	✓	✓	✓	✓
CC-19		✓	✓		✓	✓	✓

8. Semester wise credits distribution

Semester	Credit Points
M. Pharm.-I	26
M. Pharm.-II	26
M. Pharm.-III	21
M. Pharm.-IV	21
Co-curricular Activities ▪ Attending Conference [01 credit], ▪ Scientific Presentations & other Scholarly Activities [01 credit]	02
Total Credit Points =	**96**

9. Course-level Learning Outcomes

9.1.Core Courses

Core Course-1: Modern Pharmaceutical Analytical Techniques (MPL 101T)

Subject name and code	Modern Pharmaceutical Analytical Techniques (MPL 101T)
Scope	This subject deals with various advanced analytical instrumental techniques for identification, characterization and quantification of drugs. Instruments dealt are NMR, Mass spectrometer, IR, HPLC, GC etc.
Learning outcomes	After completion of course, the student is able to know about ✓ Chemicals, drugs and Excipients ✓ The analysis of various drugs in single and combination dosage forms ✓ Theoretical and practical skills of the instruments
Unit-1	UV-Visible spectroscopy: Introduction, Theory, Laws, Instrumentation associated with UV-Visible spectroscopy, Choice of solvents and solvent effect and Applications of UV-Visible spectroscopy, Difference/ Derivative spectroscopy. IR spectroscopy: Theory, Modes of Molecular vibrations, Sample handling, Instrumentation of Dispersive and Fourier – Transform IR Spectrometer, Factors affecting vibrational frequencies and Applications of IR spectroscopy, Data Interpretation. Spectroflourimetry: Theory of Fluorescence, Factors affecting fluorescence (Characteristics of drugs that can be analysed by flourimetry), Quenchers, Instrumentation and Applications of fluorescence spectrophotometer. Flame emission spectroscopy and Atomic absorption spectroscopy: Principle, Instrumentation, Interferences and Applications.
Unit-2	NMR spectroscopy: Quantum numbers and their role in NMR, Principle, Instrumentation, Solvent requirement in NMR, Relaxation process, NMR signals in various compounds, Chemical shift, Factors influencing chemical shift, Spin-Spin coupling, Coupling constant, Nuclear magnetic double resonance, Brief outline of principles of FT-NMR and 13C NMR. Applications of NMR spectroscopy.
Unit-3	Mass Spectroscopy: Principle, Theory, Instrumentation of Mass Spectroscopy, Different types of ionization like electron impact, chemical, field, FAB and MALDI, APCI, ESI, APPI Analyzers of Quadrupole and Time of Flight, Mass fragmentation and its rules, Meta stable ions, Isotopic peaks and Applications of Mass spectroscopy.

Unit-4	Chromatography: Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, isolation of drug from excipients, data interpretation and applications of the following: i. Thin Layer chromatography ii. High Performance Thin Layer Chromatography iii. Ion exchange chromatography iv. Column chromatography v. Gas chromatography vi. High Performance Liquid chromatography vii. Ultra High Performance Liquid chromatography viii. Affinity chromatography ix. Gel Chromatography
Unit-5	Electrophoresis: Principle, Instrumentation, Working conditions, factors affecting separation and applications of the following: a) Paper electrophoresis b) Gel electrophoresis c) Capillary electrophoresis d) Zone electrophoresis e) Moving boundary electrophoresis f) Iso electric focusing X ray Crystallography: Production of X rays, Different X ray methods, Bragg's law, Rotating crystal technique, X ray powder technique, Types of crystals and applications of X-ray diffraction.
Unit-6	Potentiometry: Principle, working, Ion selective Electrodes and Application of potentiometry. Thermal Techniques: Principle, thermal transitions and Instrumentation (Heat flux and power-compensation and designs), Modulated DSC, Hyper DSC, experimental parameters (sample preparation, experimental conditions, calibration, heating and cooling rates, resolution, source of errors) and their influence, advantage and disadvantages, pharmaceutical applications. Differential Thermal Analysis (DTA): Principle, instrumentation and advantage and disadvantages, pharmaceutical applications, derivative differential thermal analysis (DDTA). TGA: Principle, instrumentation, factors affecting results, advantage and disadvantages, pharmaceutical applications.

Core Course-2: Advanced Pharmacology - I (MPL 102T)

Subject name and code	Advanced Pharmacology - I (MPL 102T)
Scope	The subject is designed to strengthen the basic knowledge in the field of pharmacology and to impart recent advances in the drugs used for the treatment of various diseases. In addition, this subject helps the students to understand the concepts of drug action and mechanisms involved
Learning outcomes	After completion of course student is able to know about,

	✓ Discuss the pathophysiology and pharmacotherapy of certain diseases ✓ Explain the mechanism of drug actions at cellular and molecular level ✓ Understand the adverse effects, contraindications and clinical uses of drugs used in treatment of diseases
Unit-1	General Pharmacology a. Pharmacokinetics: The dynamics of drug absorption, distribution, biotransformation and elimination. Concepts of linear and non-linear compartment models. Significance of Protein binding. b. Pharmacodynamics: Mechanism of drug action and the relationship between drug concentration and effect. Receptors, structural and functional families of receptors, quantitation of drug receptors interaction and elicited effects.
Unit-2	Neurotransmission a. General aspects and steps involved in neurotransmission. b. Neurohumoral transmission in autonomic nervous system (Detailed study about neurotransmitters- Adrenaline and Acetylcholine). c. Neurohumoral transmission in central nervous system (Detailed study about neurotransmitters- histamine, serotonin, dopamine, GABA, glutamate and glycine]. d. Non adrenergic non cholinergic transmission (NANC). Cotransmission Systemic Pharmacology A detailed study on pathophysiology of diseases, mechanism of action, pharmacology and toxicology of existing as well as novel drugs used in the following systems Autonomic Pharmacology Parasympathomimetics and lytics, sympathomimetics and lytics, agents affecting neuromuscular junction
Unit-3	Central nervous system Pharmacology General and local anesthetics Sedatives and hypnotics, drugs used to treat anxiety. Depression, psychosis, mania, epilepsy, neurodegenerative diseases. Narcotic and non-narcotic analgesics.
Unit-4	Cardiovascular Pharmacology Diuretics, antihypertensives, antiischemics, anti- arrhythmics, drugs for heart failure and hyperlipidemia. Hematinics, coagulants, anticoagulants, fibrinolytics and antiplatelet drugs
Unit-5	Autocoid Pharmacology The physiological and pathological role of Histamine, Serotonin, Kinins Prostaglandins Opioid autocoids. Pharmacology of antihistamines, 5HT antagonists.

Core Course-3: Pharmacological and Toxicological Screening Methods-I (MPL 103T)

Subject name and code	Pharmacological and Toxicological Screening Methods-I (MPL 103T)
Scope	This subject is designed to impart the knowledge on preclinical evaluation of drugs and recent experimental techniques in the drug discovery and development. The subject content helps the student to understand the maintenance of laboratory animals as per the guidelines, basic knowledge of various in-vitro and in-vivo preclinical evaluation processes
Learning outcomes	After completion of course student is able to know about, ✓ Appraise the regulations and ethical requirement for the usage of experimental animals. ✓ Describe the various animals used in the drug discovery process and good laboratory practices in maintenance and handling of experimental animals ✓ Describe the various newer screening methods involved in the drug discovery process ✓ Appreciate and correlate the preclinical data to humans
Unit-1	Laboratory Animals Common laboratory animals: Description, handling and applications of different species and strains of animals. Transgenic animals: Production, maintenance and applications Anaesthesia and euthanasia of experimental animals. Maintenance and breeding of laboratory animals. CPCSEA guidelines to conduct experiments on animals Good laboratory practice. Bioassay-Principle, scope and limitations and methods
Unit-2	Preclinical screening of new substances for the pharmacological activity using in vivo, in vitro, and other possible animal alternative models. General principles of preclinical screening. CNS Pharmacology: behavioral and muscle coordination, CNS stimulants and depressants, anxiolytics, anti-psychotics, anti-epileptics and nootropics. Drugs for neurodegenerative diseases like Parkinsonism, Alzheimer's and multiple sclerosis. Drugs acting on Autonomic Nervous System.
Unit-3	Preclinical screening of new substances for the pharmacological activity using in vivo, in vitro, and other possible animal alternative models. Respiratory Pharmacology: anti-asthmatics, drugs for COPD and anti-allergics. Reproductive Pharmacology: Aphrodisiacs and antifertility agents Analgesics, anti-inflammatory and antipyretic agents. Gastrointestinal drugs: anti-ulcer, anti - emetic, antidiarrheal and laxatives.
Unit-4	Preclinical screening of new substances for the pharmacological activity using in vivo, in vitro, and other possible animal alternative models.

	Cardiovascular Pharmacology: antihypertensives, antiarrythmics, antianginal, antiatherosclerotic agents and diuretics. Drugs for metabolic disorders like anti-diabetic, antidyslipidemic agents. Anti-cancer agents. Hepatoprotective screening methods
Unit-5	Preclinical screening of new substances for the pharmacological activity using in vivo, in vitro, and other possible animal alternative models. Iimmunomodulators, Immunosuppressants and immunostimulants General principles of immunoassay: theoretical basis and optimization of immunoassay, heterogeneous and homogenous immunoassay systems. Immunoassay methods evaluation; protocol outline, objectives and preparation. Immunoassay for digoxin and insulin Limitations of animal experimentation and alternate animal experiments. Extrapolation of in vitro data to preclinical and preclinical to humans

Core Course-4: Cellular and Molecular Pharmacology (MPL 104T)

Subject name and code	Cellular and Molecular Pharmacology (MPL 104T)
Scope	The subject imparts a fundamental knowledge on the structure and functions of cellular components and help to understand the interaction of these components with drugs. This information will further help the student to apply the knowledge in drug discovery process.
Learning outcomes	After completion of course student is able to know about, ✓ Explain the receptor signal transduction processes. ✓ Explain the molecular pathways affected by drugs. ✓ Appreciate the applicability of molecular pharmacology and biomarkers in drug discovery process. ✓ Demonstrate molecular biology techniques as applicable for pharmacology
Unit-1	Cell biology Structure and functions of cell and its organelles Genome organization. Gene expression and its regulation, importance of siRNA and micro RNA, gene mapping and gene sequencing Cell cycles and its regulation. Cell death– events, regulators, intrinsic and extrinsic pathways of apoptosis. Necrosis and autophagy.
Unit-2	Cell signaling Intercellular and intracellular signaling pathways. Classification of receptor family and molecular structure ligand

	gated ion channels; G-protein coupled receptors, tyrosine kinase receptors and nuclear receptors. Secondary messengers: cyclic AMP, cyclic GMP, calcium ion, inositol 1,4,5-trisphosphate, (IP3), NO, and diacylglycerol. Detailed study of following intracellular signaling pathways: cyclic AMP signaling pathway, mitogen-activated protein kinase (MAPK) signaling, Janus kinase (JAK)/signal transducer and activator of transcription (STAT) signaling pathway.
Unit-3	Principles and applications of genomic and proteomic tools DNA electrophoresis, PCR (reverse transcription and real time), Gene sequencing, micro array technique, SDS page, ELISA and western blotting, Recombinant DNA technology and gene therapy Basic principles of recombinant DNA technology-Restriction enzymes, various types of vectors. Applications of recombinant DNA technology. Gene therapy- Various types of gene transfer techniques, clinical applications and recent advances in gene therapy.
Unit-4	Pharmacogenomics Gene mapping and cloning of disease gene. Genetic variation and its role in health/ pharmacology Polymorphisms affecting drug metabolism Genetic variation in drug transporters Genetic variation in G protein coupled receptors Applications of proteomics science: Genomics, proteomics, metabolomics, functionomics, nutrigenomics Immunotherapeutics Types of immunotherapeutics, humanisation antibody therapy, Immunotherapeutics in clinical practice
Unit-5	A. Cell culture techniques Basic equipments used in cell culture lab. Cell culture media, various types of cell culture, general procedure for cell cultures; isolation of cells, subculture, cryopreservation, characterization of cells and their application. Principles and applications of cell viability assays, glucose uptake assay, Calcium influx assays Principles and applications of flow cytometry B. Biosimilars

Core Course-5: Pharmacology Practical - I (MPL 105P)

PART-A:

1. Analysis of pharmacopoeial compounds and their formulations by UV Vis spectrophotometer
2. Simultaneous estimation of multi component containing formulations by UV spectrophotometry
3. Experiments based on HPLC
4. Experiments based on Gas Chromatography
5. Estimation of riboflavin/quinine sulphate by fluorimetry
6. Estimation of sodium/potassium by flame photometry Handling of laboratory animals.

PART-B:

1. Various routes of drug administration.
2. Techniques of blood sampling, anesthesia and euthanasia of experimental animals.
3. Functional observation battery tests (modified Irwin test)
4. Evaluation of CNS stimulant, depressant, anxiogenics and anxiolytic, anticonvulsant activity.
5. Evaluation of analgesic, anti-inflammatory, local anesthetic, mydriatic and miotic activity.
6. Evaluation of diuretic activity.
7. Evaluation of antiulcer activity by pylorus ligation method.
8. Oral glucose tolerance test.
9. Isolation and identification of DNA from various sources (Bacteria, Cauliflower, onion, Goat liver).
10. Isolation of RNA from yeast
11. Estimation of proteins by Braford/Lowry's in biological samples.
12. Estimation of RNA/DNA by UV Spectroscopy
13. Gene amplification by PCR.
14. Protein quantification Western Blotting.
15. Enzyme based in-vitro assays (MPO, AChEs, α amylase, α glucosidase).
16. Cell viability assays (MTT/Trypan blue/SRB).
17. DNA fragmentation assay by agarose gel electrophoresis.
18. DNA damage study by Comet assay.
19. Apoptosis determination by fluorescent imaging studies.
20. Pharmacokinetic studies and data analysis of drugs given by different routes of administration using software
21. Enzyme inhibition and induction activity
22. Extraction of drug from various biological samples and estimation of drugs in biological fluids using different analytical techniques (UV)
23. Extraction of drug from various biological samples and estimation of drugs in biological fluids using different analytical techniques (HPLC)

Core Course-7: Advanced Pharmacology II (MPL 201T)

Subject name and code	Advanced Pharmacology II (MPL 201T)
Scope	The subject is designed to strengthen the basic knowledge in the field of pharmacology and to impart recent advances in the drugs used for the treatment of various diseases. In addition, the subject helps the student to understand the concepts of drug action and mechanism involved
Learning outcomes	✓ Upon completion of the course the student shall be able to: Explain the mechanism of drug actions at cellular and molecular level ✓ Discuss the Pathophysiology and pharmacotherapy of certain diseases ✓ Understand the adverse effects, contraindications and clinical uses of drugs used in treatment of diseases
Unit-1	Endocrine Pharmacology Molecular and cellular mechanism of action of hormones such as growth hormone, prolactin, thyroid, insulin and sex hormones Anti-thyroid drugs, Oral hypoglycemic agents, Oral contraceptives, Corticosteroids. Drugs affecting calcium regulation
Unit-2	Chemotherapy Cellular and molecular mechanism of actions and resistance of antimicrobial agents such as ß-lactams, aminoglycosides, quinolones, Macrolide antibiotics. Antifungal, antiviral, and anti-TB drugs.
Unit-3	Chemotherapy Drugs used in Protozoal Infections Drugs used in the treatment of Helminthiasis Chemotherapy of cancer Immunopharmacology Cellular and biochemical mediators of inflammation and immune response. Allergic or hypersensitivity reactions. Pharmacotherapy of asthma and COPD. Immunosuppressants and Immunostimulants
Unit-4	GIT Pharmacology Antiulcer drugs, Prokinetics, antiemetics, anti-diarrheals and drugs for constipation and irritable bowel syndrome. Chronopharmacology Biological and circadian rhythms, applications of chronotherapy in various diseases like cardiovascular disease, diabetes, asthma and peptic ulcer
Unit-5	Generation of free radicals, role of free radicals in etiopathology of various diseases such as diabetes, neurodegenerative diseases and cancer. Protective activity of certain important antioxidant Recent Advances in Treatment: Alzheimer's disease, Parkinson's disease, Cancer, Diabetes mellitus

Core Course-8: Pharmacological and Toxicological Screening Methods-II (MPL 202T)

Subject name and code	Pharmacological and Toxicological Screening Methods-II (MPL 202T)
Scope	This subject imparts knowledge on the preclinical safety and toxicological evaluation of drug & new chemical entity. This knowledge will make the student competent in regulatory toxicological evaluation.
Learning outcomes	✓ Upon completion of the course, the student shall be able to, Explain the various types of toxicity studies. ✓ Appreciate the importance of ethical and regulatory requirements for toxicity studies. ✓ Demonstrate the practical skills required to conduct the preclinical toxicity studies.
Unit-1	Basic definition and types of toxicology (general, mechanistic, regulatory and descriptive) Regulatory guidelines for conducting toxicity studies OECD, ICH, EPA and Schedule Y OECD principles of Good laboratory practice (GLP) History, concept and its importance in drug development
Unit-2	Acute, sub-acute and chronic- oral, dermal and inhalational studies as per OECD guidelines. Acute eye irritation, skin sensitization, dermal irritation & dermal toxicity studies. Test item characterization- importance and methods in regulatory toxicology studies
Unit-3	Reproductive toxicology studies, Male reproductive toxicity studies, female reproductive studies (segment I and segment III), teratogenecity studies (segment II) Genotoxicity studies (Ames Test, in vitro and in vivo Micronucleus and Chromosomal aberrations studies) In vivo carcinogenicity studies
Unit-4	IND enabling studies (IND studies)- Definition of IND, importance of IND, industry perspective, list of studies needed for IND submission. Safety pharmacology studies- origin, concepts and importance of safety pharmacology. Tier1- CVS, CNS and respiratory safety pharmacology, HERG assay. Tier2- GI, renal and other studies
Unit-5	Toxicokinetics- Toxicokinetic evaluation in preclinical studies, saturation kinetics Importance and applications of toxicokinetic studies. Alternative methods to animal toxicity testing.

Core Course-9: Principles of Drug Discovery (MPL 203T)

Subject name and code	Principles of Drug Discovery (MPL 203T)
Scope	The subject imparts basic knowledge of drug discovery process. This information will make the student competent in drug discovery process
Learning outcomes	Upon completion of the course, the student shall be able to ✓ Explain the various stages of drug discovery. ✓ Appreciate the importance of the role of genomics, proteomics and bioinformatics in drug discovery ✓ Explain various targets for drug discovery. ✓ Explain various lead seeking method and lead optimization ✓ Appreciate the importance of the role of computer aided drug design in drug discovery
Unit-1	An overview of modern drug discovery process: Target identification, target validation, lead identification and lead Optimization. Economics of drug discovery. Target Discovery and Validation-Role of Genomics, Proteomics and Bioinformatics. Role of Nucleic acid microarrays, Protein microarrays, Antisense technologies, siRNAs, antisense oligonucleotides, Zinc finger proteins. Role of transgenic animals in target validation.
Unit-2	Lead Identification- combinatorial chemistry & high throughput screening, in silico lead discovery techniques, Assay development for hit identification. Protein structure: Levels of protein structure, Domains, motifs, and folds in protein structure. Computational prediction of protein structure: Threading and homology modeling methods. Application of NMR and X-ray crystallography in protein structure prediction
Unit-3	Rational Drug Design Traditional vs rational drug design, Methods followed in traditional drug design, High throughput screening, Concepts of Rational Drug Design, Rational Drug Design Methods: Structure and Pharmacophore based approaches Virtual Screening techniques: Drug likeness screening, Concept of pharmacophore mapping and pharmacophore based Screening
Unit-4	Molecular docking: Rigid docking, flexible docking, manual docking; Docking based screening. De novo drug design. Quantitative analysis of Structure Activity Relationship History and development of QSAR, SAR versus QSAR, Physicochemical parameters, Hansch analysis, Fee Wilson analysis and relationship between them.
Unit-5	QSAR Statistical methods – regression analysis, partial least square analysis (PLS) and other multivariate statistical methods. 3D-QSAR approaches like COMFA and COMSIA Prodrug Design-Basic concept, Prodrugs to improve patient acceptability, Drug solubility, Drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug design and practical consideration of prodrug design

Core Course-10: Clinical Research and Pharmacovigilance (MPL 204T)

Subject name and code	Clinical Research and Pharmacovigilance (MPL 204T)
Scope	This subject will provide a value addition and current requirement for the students in clinical research and pharmacovigilance. It will teach the students on conceptualizing, designing, conducting, managing and reporting of clinical trials. This subject also focuses on global scenario of Pharmacovigilance in different methods that can be used to generate safety data. It will teach the students in developing drug safety data in Pre-clinical, Clinical phases of Drug development and post market surveillance.
Learning outcomes	Upon completion of the course, the student shall be able to, ✓ Explain the regulatory requirements for conducting clinical trial ✓ Demonstrate the types of clinical trial designs ✓ Explain the responsibilities of key players involved in clinical trials ✓ Execute safety monitoring, reporting and close-out activities ✓ Explain the principles of Pharmacovigilance ✓ Detect new adverse drug reactions and their assessment ✓ Perform the adverse drug reaction reporting systems and ✓ communication in Pharmacovigilance
Unit-1	Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines Ethical Committee: Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant-Schedule Y, ICMR Informed Consent Process: Structure and content of an Informed Consent Process Ethical principles governing informed consent process
Unit-2	Clinical Trials: Types and Design Experimental Study- RCT and Non RCT, Observation Study: Cohort, Case Control, Cross sectional Clinical Trial Study Team Roles and responsibilities of Clinical Trial Personnel: Investigator, Study Coordinator, Sponsor, Contract Research Organization and its management
Unit-3	Clinical Trial Documentation- Guidelines to the preparation of documents, Preparation of protocol, Investigator Brochure, Case Report Forms, Clinical Study Report Clinical Trial Monitoring-Safety Monitoring in CT Adverse Drug Reactions: Definition and types. Detection and reporting methods. Severity and seriousness assessment. Predictability and preventability assessment, Management of adverse drug reactions; Terminologies of ADR.

Unit-4	Basic aspects, terminologies and establishment of pharmacovigilance History and progress of pharmacovigilance, Significance of safety monitoring, Pharmacovigilance in India and international aspects, WHO international drug monitoring programme, WHO and Regulatory terminologies of ADR, evaluation of medication safety, Establishing pharmacovigilance centres in Hospitals, Industry and National programmes related to pharmacovigilance. Roles and responsibilities in Pharmacovigilance
Unit-5	Methods, ADR reporting and tools used in Pharmacovigilance International classification of diseases, International Nonproprietary names for drugs, Passive and Active surveillance, Comparative observational studies, Targeted clinical investigations and Vaccine safety surveillance. Spontaneous reporting system and Reporting to regulatory authorities, Guidelines for ADRs reporting. Argus, Aris G Pharmacovigilance, VigiFlow, Statistical methods for evaluating medication safety data.
Unit-6	Pharmacoepidemiology, Pharmacoeconomics, Safety pharmacology

Core Course-11: Pharmacology Practical II (MPL 205P)

1. To record the DRC of agonist using suitable isolated tissues preparation. 2. To study the effects of antagonist/potentiating agents on DRC of agonist using suitable isolated tissue preparation. 3. To determine to the strength of unknown sample by matching bioassay by using suitable tissue preparation. 4. To determine to the strength of unknown sample by interpolation bioassay by using uitable tissue preparation 5. To determine to the strength of unknown sample by bracketing bioassay by using suitable tissue preparation 6. To determine to the strength of unknown sample by multiple point bioassay by using suitable tissue preparation. 7. Estimation of PA2 values of various antagonists using suitable isolated tissue preparations. 8. To study the effects of various drugs on isolated heart preparations 9. Recording of rat BP, heart rate and ECG. 10. Recording of rat ECG 11. Drug absorption studies by averted rat ileum preparation.

12. Acute oral toxicity studies as per OECD guidelines. 13. Acute dermal toxicity studies as per OECD guidelines. 14. Repeated dose toxicity studies- Serum biochemical, haematological, urine analysis, functional observation tests and histological studies. 15. Drug mutagenicity study using mice bone-marrow chromosomal aberration test. 16. Protocol design for clinical trial.(3 Nos.) 17. Design of ADR monitoring protocol. 18. In-silico docking studies. (2 Nos.) 19. In-silico pharmacophore based screening. 20. In-silico QSAR studies. 21. ADR reporting

Core Course-13: Research Methodology & Biostatistics (MPL 301T)

Subject name and code	Research Methodology & Biostatistics (MPL 301T)
Unit-1	General Research Methodology: Research, objective, requirements, practical difficulties, review of literature, study design, types of studies, strategies to eliminate errors/bias, controls, randomization, crossover design, placebo, blinding techniques.
Unit-2	Biostatistics: Definition, application, sample size, importance of sample size, factors influencing sample size, dropouts, statistical tests of significance, type of significance tests, parametric tests (students "t" test, ANOVA, Correlation coefficient, regression), non-parametric tests (wilcoxan rank tests, analysis of variance, correlation, chi square test), null hypothesis, P values, degree of freedom, interpretation of P values.
Unit-3	Medical Research: History, values in medical ethics, autonomy, beneficence, non-maleficence, double effect, conflicts between autonomy and beneficence/non-maleficence, euthanasia, informed consent, confidentiality, criticisms of orthodox medical ethics, importance of communication, control resolution, guidelines, ethics committees, cultural concerns, truth telling, online business practices, conflicts of interest, referral, vendor relationships, treatment of family members, sexual relationships, fatality.
Unit-4	CPCSEA guidelines for laboratory animal facility: Goals, veterinary care, quarantine, surveillance, diagnosis, treatment and control of disease, personal hygiene, location of animal facilities to laboratories, anesthesia, euthanasia, physical facilities, environment, animal husbandry, record keeping, SOPs, personnel and training, transport of lab animals.

Unit-5	Declaration of Helsinki: History, introduction, basic principles for all medical research, and additional principles for medical research combined with medical care.

9.2. Elective Courses for other Departments

GEC-1: Clinical Research **Course Code: SIAS PS 02 01 01 E 4004**

Subject name	Clinical Research
Scope	The subject will impart the fundamental knowledge on the clinical drug development process of drugs.
Learning outcomes	The students shall be able to learn the ✓ Different aspects of clinical trial ✓ Ethics in clinical research ✓ Regulatory Perspectives of Clinical Trials ✓ types of clinical trial designs ✓ responsibilities of key players involved in clinical trials
Unit-1	Clinical Drug Development Process Different types of Clinical Studies, Phases of clinical trials, Clinical Trial protocol, Phase 0 studies, Phase I Phase II studies, Phase III studies, Phase IV studies (Post Marketing Studies; PSUR) Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines Ethical Committee: Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant- Schedule Y, ICMR
Unit-2	Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines Ethical Committee: Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant- Schedule Y, ICMR
Unit-3	Clinical Trials: Types and Design Experimental Study- RCT and Non RCT, Observation Study: Cohort, Case Control, Cross sectional Clinical Trial Study Team Roles and responsibilities of Clinical Trial Personnel: Investigator, Study Coordinator, Sponsor, Contract Research Organization and its management

GEC-2: Pharmacovigilance **Course Code: SIAS PS 02 02 01 E 4004**

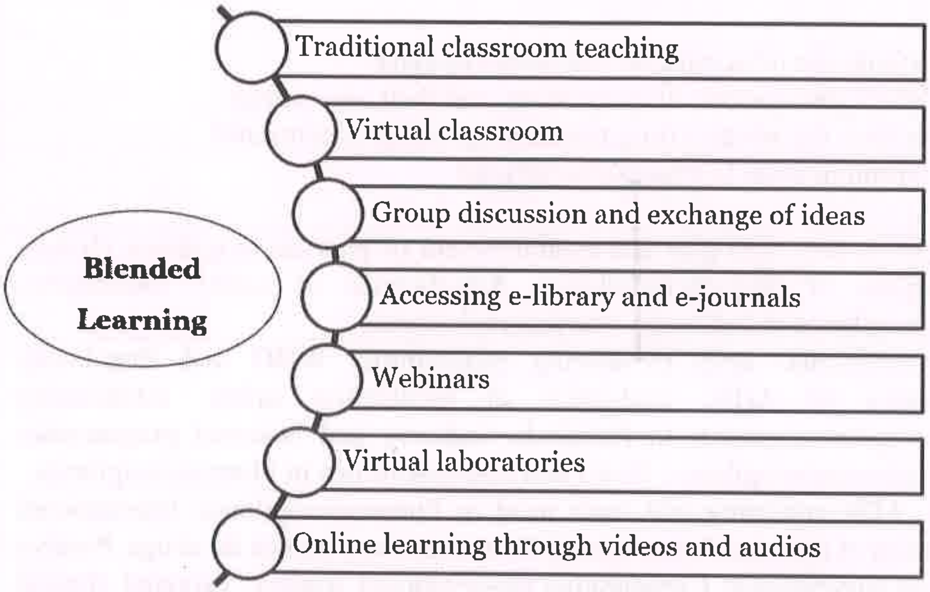
Subject name	Pharmacovigilance
Scope	The subject will impart advanced knowledge on methods, tools and significance of Pharmacovigilance
Learning outcomes	The students shall be able to learn the ✓ Explain the principles of Pharmacovigilance ✓ Detect new adverse drug reactions and their assessment ✓ Perform the adverse drug reaction reporting systems and communication in Pharmacovigilance
Unit-1	Basic aspects, terminologies and establishment of pharmacovigilance History and progress of pharmacovigilance, Significance of safety monitoring, Pharmacovigilance in India and international aspects
Unit-2	WHO international drug monitoring programme, WHO and Regulatory terminologies of ADR, evaluation of medication safety, establishing pharmacovigilance centres in Hospitals, Industry and National programmes related to pharmacovigilance. Roles and responsibilities in Pharmacovigilance
Unit-3	Methods, ADR reporting and tools used in Pharmacovigilance International classification of diseases, International Nonproprietary names for drugs, Passive and Active surveillance, Comparative observational studies, Targeted clinical investigations and Vaccine safety surveillance.
Unit-4	Spontaneous reporting system and Reporting to regulatory authorities, Guidelines for ADRs reporting. Argus, Aris G Pharmacovigilance, VigiFlow, Statistical methods for evaluating medication safety data.

10.Teaching-Learning Process

1. Classroom Lectures
2. Interactive sessions
3. Animation and videos demonstration
4. Quizzes
5. Flipped classroom
6. Group discussions
7. Seminars
8. Electronic learning
9. Tutorials
10. Laboratory demonstrations
11. Collaborative Learning
12. Self-assessed or peer-assessed assignments

11. Blended Learning

A concept that includes framing teaching learning process and incorporates both face to face teaching and teaching supported by ICT. Blended learning incorporates direct as well as indirect instruction, collaborative teaching learning, and individualized computer-assisted learning.



12. Assessment and Evaluation

Internal assessment: Continuous mode

Subject type	Criteria	Maximum Marks
Theory	Attendance	8
	Student – Teacher interaction	2
	Total	**10**
Practical	Attendance	10
	Based on Practical Records, Regular viva voce, etc.	10
	Total	**20**

Scheme for awarding internal assessment: Continuous mode

Guidelines for the allotment of marks for attendance

Percentage of Attendance	Theory	Practical

95 – 100	8	10
90 – 94	6	7.5
85 – 89	4	5
80 – 84	2	2.5
Less than 80	0	0

- Mid-semester and Comprehensive End-term Examination of courses
- Continuous evaluation in the form of
    - ✓ Class work,
    - ✓ Check-in assessment
    - ✓ Periodical quizzes,
    - ✓ Group discussions
    - ✓ Surprise tests,
    - ✓ Tutorials,
    - ✓ Laboratory work evaluation
- Collaborative Assignments
- Open book learning to assess problem solving and analytical abilities
- Oral presentations
- Multiple choice examination
- Problem solving exercises in groups

13.Keywords

- NEP-2020
- Blended Learning
- Programme Educational Objectives (PEOs)
- Learning Outcomes
- Programme Outcomes
- Postgraduate Attributes
- Continuous Mode
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Learning Outcome Index
- Teaching-Learning Process

14. References

1. National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
2. Pharmacy council of India, M. Pharm Syllabus https://www.pci.nic.in/pdf/Syllabus_M_Pharm.pdf
3. Blended Mode of Teaching and Learning: Concept Note. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

Annexure-XXI

Learning Outcome-based Curriculum Framework for M. Pharm (Pharmacognosy)

[NEP-2020]

2022-23

6/10/2022

06/10/2022

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Table of contents

1. Background

1.1. Introduction to Department of Pharmaceutical Sciences

The Department of Pharmaceutical Sciences was established in 2020 as a flagship department of Central University of Haryana to provide quality education and training to pharmacy graduates to become highly skilled and caring healthcare professionals and create new knowledge through excellence in basic and translational pharmaceutical research. The department is currently offering **M. Pharm. (Pharmacognosy)** course for Pharmacy graduates duly approved by Pharmacy Council of India (PCI), New Delhi. The department has engaged experienced, vibrant and well-qualified faculties involved in both teaching and research work. The faculty members have published a substantial number of research papers in journals of national and International repute.

The department is focussed to train the students/scholars in emerging fields of pharmacy catering to pharmaceutical industry and R&D. We have a vision to train and nurture the students towards fundamental & advanced research in pharmacy leading to technological innovation and entrepreneurship. Having collaborations with prominent national and international institutions in future, the department aims to carry out collaborative research in thrust areas of health and medicines.

The department also plans to initiate the research in the field of Natural products in future with focus to identify novel targets and explore their pharmacological benefits in the treatment of various ailments/disorders. The Department of Pharmaceutical Sciences aims at identifying and characterising both new biologically active natural products and their semisynthetic derivatives and at understanding their interactions with human targets on a molecular level using in-silico, in-vitro, and in-vivo models. Based on this knowledge, new lead compounds and disease-relevant targets will be investigated and novel delivery systems for pharmaceutical active ingredients will be developed. Main areas of research include:

a) EthnoPharmacognosy of Indigenous medicinal plants
b) Development of Nanoformulations of selected Natural Products and their evaluation
c) Standardization and characterization of Ayurvedic/Homeopathic/Unani herbal formulations
d) NeuroPharmacognosy
e) Pharmacovigilance

M. Pharm. (Pharmacognosy) provides unprecedented opportunities in Pharmaceutical industries focussed on Standardization and Characterization of herbs & Herbal formulations, Development and Evaluation of Herbal formulations, Regulatory aspects, Intellectual property rights (IPR) and Pharmacovigilance of herbal medicines/natural products.

1.2.Vision of the Department

- To contribute in the innovation and leadership of healthcare system through superior dissemination of Pharmaceutical knowledge.

1.3.Mission of the Department

- To nurture the young minds towards fundamental & advanced Pharmaceutical research that contribute to the technological innovation and entrepreneurship.
- To provide an integrated and rigorous coursework to fulfil the needs of Pharmaceutical industry and society.
- To create a centre of excellence by building collaborations with industry and research institutions.

2. Program Educational Objectives (PEOs)

- **PEO-1:** The Postgraduate students will integrate basic Pharmacognosy knowledge and skills with healthcare requirements of the society.
- **PEO-2:** The Postgraduate students will have a comprehensive knowledge of different classes of phytoconstituents, their properties, extraction and general process of natural product drug discovery.
- **PEO-3:** The Postgraduate students will learn the guidelines for quality of herbal/natural medicines and their regulatory issues.
- **PEO-4:** The Postgraduate students will learn the specific requirement for setting up the herbal drug industry.
- **PEO-5:** The Postgraduate students will learn validation of herbal remedies, methods of detection of adulteration and evaluation techniques for the herbal drugs.
- **PEO-6:** The Postgraduate students will learn about the basic principles of alternative systems of medicines.

- **PEO-7:** The Postgraduate students will learn current Good manufacturing practices (GMPs) of herbal cosmeceuticals.
- **PEO-8:** The Postgraduate students will become competent by applying their technical, and leadership skills in pharmaceutical research.

3. Program Outcomes

- **PO-1: Basic and applied knowledge:** Interdisciplinary knowledge to find solution for the complex biological problems
- **PO-2: Problem analysis:** Ability to analyse society related/ applied research problem, design and execute experiments to find relevant solutions
- **PO-3: Advanced Usage of Technology:** Apply advanced instrumentation tools, online resources with an understanding of the troubleshooting and limitations
- **PO-4: Ethics:** Commitment towards professional ethics and responsibilities as a social endeavour to bring harmony with nature
- **PO-5: Lifelong learning:** Scientific skills for industrial applications and entrepreneurship

4. Programme Specific Outcomes (PSOs)

- **PSO-1:** To provide the efficient knowledge of fundamental concepts of Pharmacognosy.
- **PSO-2:** Analysis and problem solving capability in the field of pharmaceutical sciences.
- **PSO-3:** To develop the professional skills in the area of Pharmacognosy/Natural products to meet global demand and look for opportunities in Pharmaceutical industries.
- **PSO-4:** To give exposure of latest tools and techniques utilized in herbal drug industry.
- **PSO-5:** To give an immersive professional experience to adapt in a globe of constantly developing trend.
- **PSO-6:** To inculcate professional ethics, communication skills and leadership skills.
- **PSO-7:** To develop students' ability to provide advice on the utilization of herbs and herbal medicines and the promotion of drug safety.

5. Postgraduate Attributes

- Pharmacy Knowledge
- Problem analysis
- Design and conduct the investigations of complex problems
- Modern tool usage
- Pharmacist and Society
- Leadership skills
- Communication skills
- Environment and sustainability
- Life-long learning
- Research ethics

6. Structure of Course (M. Pharm. Pharmacognosy)

Semester-I							
Core Course	**Course Code**	**Course**	**Credit Points**	**L**	**T**	**P**	**S**
1	MPG 101T	Modern Pharmaceutical Analytical Techniques	4	4	0	0	0
2	MPG 102T	Advanced Pharmacognosy-I	4	4	0	0	0
3	MPG 103T	Phytochemistry	4	4	0	0	0
4	MPG 104T	Industrial Pharmacognostical Technology	4	4	0	0	0
5	MPG 105P	Pharmacognosy Practical-I	6	0	0	12	0
6	MPG 106S	Seminar/Assignment	4	0	0	0	7

Semester-II

Core Course	Course Code	Course	Credit Points	L	T	P	S
7	MPG 201T	Medicinal Plant Biotechnology	4	4	0	0	0
8	MPG 202T	Advanced Pharmacognosy-II	4	4	0	0	0
9	MPG 203T	Indian system of medicine	4	4	0	0	0
10	MPG 204T	Herbal cosmetics	4	4	0	0	0
11	MPG 205P	Pharmacognosy Practical-II	6	0	0	12	0
12	MPG 206S	Seminar/Assignment	4	0	0	0	7

Semester-III

Core Course	Course Code	Course	Credit Hours	Credit Points
13	MPG 301T	Research Methodology and Biostatistics	4	4
14	MPG 302	Journal club	1	1
15	MPG 303	Discussion / Presentation (Proposal Presentation)	2	2
16	MPG 304	Research Work	28	14

Semester-IV

Core Course	Course Code	Course	Credit Hours	Credit Points
17	MPG 401	Journal club	1	1
18	MPG 402	Research Work	31	16
19	MPG 403	Discussion/Final Presentation	4	4

7. Learning Outcome Index (Core Courses)

PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7
CC-1		✓	✓	✓	✓		
CC-2	✓	✓	✓	✓	✓	✓	✓
CC-3	✓	✓	✓	✓	✓	✓	✓
CC-4	✓	✓	✓	✓	✓	✓	✓
CC-5	✓	✓	✓	✓	✓	✓	✓
CC-6	✓	✓	✓	✓	✓	✓	✓
CC-7	✓	✓	✓	✓	✓	✓	
CC-8	✓	✓	✓	✓	✓	✓	✓
CC-9	✓	✓	✓	✓	✓	✓	✓
CC-10		✓	✓	✓	✓	✓	✓
CC-11		✓	✓	✓	✓		✓
CC-12	✓	✓	✓	✓	✓	✓	✓
CC-13		✓	✓	✓	✓	✓	
CC-14		✓		✓	✓	✓	✓
CC-15		✓	✓		✓	✓	✓
CC-16		✓	✓	✓	✓	✓	✓
CC-17		✓		✓	✓	✓	✓
CC-18		✓	✓	✓	✓	✓	✓
CC-19		✓	✓		✓	✓	✓

8. Semester wise credits distribution

Semester	**Credit Points**
M. Pharm.-I	26
M. Pharm.-II	26
M. Pharm.-III	21
M. Pharm.-IV	21
Co-curricular Activities Attending Conference [01 credit], ▪ Scientific Presentations & other Scholarly Activities [01 credit]	02
Total Credit Points =	**96**

9. Course-level Learning Outcomes

9.1.Core Courses

Core Course-1: Modern Pharmaceutical Analytical Techniques (MPG 101T)

Subject name and code	Modern Pharmaceutical Analytical Techniques (MPG 101T)
Scope	This subject deals with various advanced analytical instrumental techniques for identification, characterization and quantification of drugs. Instruments dealt are NMR, Mass spectrometer, IR, HPLC, GC etc.
Learning outcomes	After completion of course, the student is able to know about ✓ Chemicals, drugs and Excipients ✓ The analysis of various drugs in single and combination dosage forms ✓Theoretical and practical skills of the instruments
Unit-1	UV-Visible spectroscopy: Introduction, Theory, Laws, Instrumentation associated with UV-Visible spectroscopy, Choice of solvents and solvent effect and Applications of UV-Visible spectroscopy, Difference/ Derivative spectroscopy. IR spectroscopy: Theory, Modes of Molecular vibrations, Sample handling, Instrumentation of Dispersive and Fourier – Transform IR Spectrometer, Factors affecting vibrational frequencies and Applications of IR spectroscopy, Data Interpretation. Spectroflourimetry: Theory of Fluorescence, Factors affecting fluorescence (Characteristics of drugs that can be analysed by flourimetry), Quenchers, Instrumentation and Applications of fluorescence spectrophotometer. Flame emission spectroscopy and Atomic absorption spectroscopy: Principle, Instrumentation, Interferences and Applications.
Unit-2	NMR spectroscopy: Quantum numbers and their role in NMR, Principle, Instrumentation, Solvent requirement in NMR, Relaxation process, NMR signals in various compounds, Chemical shift, Factors influencing chemical shift, Spin-Spin coupling, Coupling constant, Nuclear magnetic double resonance, Brief outline of principles of FT-NMR and 13C NMR. Applications of NMR spectroscopy.
Unit-3	Mass Spectroscopy: Principle, Theory, Instrumentation of Mass Spectroscopy, Different types of ionization like electron impact, chemical, field, FAB and MALDI, APCI, ESI, APPI Analyzers of Quadrupole and Time of Flight, Mass fragmentation and its rules, Meta stable ions, Isotopic peaks and Applications of Mass spectroscopy.
Unit-4	Chromatography: Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, isolation of drug from excipients, data interpretation and applications of the following:

	i. Thin Layer chromatography ii. High Performance Thin Layer Chromatography iii. Ion exchange chromatography iv. Column chromatography v. Gas chromatography vi. High Performance Liquid chromatography vii. Ultra High Performance Liquid chromatography viii. Affinity chromatography ix. Gel Chromatography
Unit-5	Electrophoresis: Principle, Instrumentation, Working conditions, factors affecting separation and applications of the following: a) Paper electrophoresis b) Gel electrophoresis c) Capillary electrophoresis d) Zone electrophoresis e) Moving boundary electrophoresis f) Iso electric focusing X ray Crystallography: Production of X rays, Different X ray methods, Bragg's law, Rotating crystal technique, X ray powder technique, Types of crystals and applications of X-ray diffraction.
Unit-6	Potentiometry: Principle, working, Ion selective Electrodes and Application of potentiometry. Thermal Techniques: Principle, thermal transitions and Instrumentation (Heat flux and power-compensation and designs), Modulated DSC, Hyper DSC, experimental parameters (sample preparation, experimental conditions, calibration, heating and cooling rates, resolution, source of errors) and their influence, advantage and disadvantages, pharmaceutical applications. Differential Thermal Analysis (DTA): Principle, instrumentation and advantage and disadvantages, pharmaceutical applications, derivative differential thermal analysis (DDTA). TGA: Principle, instrumentation, factors affecting results, advantage and disadvantages, pharmaceutical applications.

Core Course-2: Advanced Pharmacognosy - I (MPG 102T)

Subject name and code	Advanced Pharmacognosy - I (MPG 102T)
Scope	To learn and understand the advances in the field of cultivation and isolation of drugs of natural origin, various phytopharmaceuticals, nutraceuticals and their medicinal use and health benefits.
Learning outcomes	After completion of course student is able to know about, ✓ advances in the cultivation and production of drugs ✓ various phyto-pharmaceuticals and their source, its utilization and medicinal value. ✓ various nutraceuticals/herbs and their health benefits ✓ Drugs of marine origin ✓ Pharmacovigilance of drugs of natural origin

Unit-1	Plant drug cultivation: General introduction to the importance of Pharmacognosy in herbal drug industry, Indian Council of Agricultural Research, Current Good Agricultural Practices, Current Good Cultivation Practices, Current Good Collection Practices, Conservation of medicinal plants- Ex-situ and In-situ conservation of medicinal plants.
Unit-2	Marine natural products: General methods of isolation and purification, Study of Marine toxins, Recent advances in research in marine drugs, Problems faced in research on marine drugs such as taxonomical identification, chemical screening and their solution.
Unit-3	Nutraceuticals: Current trends and future scope, Inorganic mineral supplements, Vitamin supplements, Digestive enzymes, Dietary fibres, Cereals and grains, Health drinks of natural origin, Antioxidants, Polyunsaturated fatty acids, Herbs as functional foods, Formulation and standardization of neutraceuticals, Regulatory aspects, FSSAI guidelines, Sources, name of marker compounds and their chemical nature, medicinal uses and health benefits of following i) Spirulina ii) Soya bean iii) Ginseng iv) Garlic v) Broccoli vi) Green and Herbal Tea vii) Flax seeds viii) Black cohosh ix) Turmeric.
Unit-4	Phytopharmaceuticals: Occurrence, isolation and characteristic features (Chemical nature, uses in pharmacy, medicinal and health benefits) of following. a) Carotenoids – i) α and β - Carotene ii) Xanthophyll (Lutein) b) Limonoids – i) d-Limonene ii) α – Terpineol c) Saponins – i) Shatavarins d) Flavonoids – i) Resveratrol ii) Rutin iii) Hesperidin iv) Naringin v) Quercetin e) Phenolic acids- Ellagic acid f) Vitamins g) Tocotrienols and Tocopherols h) Andrographolide, Glycolipids, Gugulipids, Withanolides, Vascine, Taxol i) Miscellaneous
Unit-5	Pharmacovigilance of drugs of natural origin: WHO and AYUSH guidelines for safety monitoring of natural medicine, Spontaneous reporting schemes for biodrug adverse reactions, bio drug-drug and bio drug-food interactions with suitable examples.

Core Course-3: Phytochemistry (MPG 103T)

Subject name and code	Phytochemistry (MPG 103T)
Scope	Students shall be equipped with the knowledge of natural product drug discovery and will be able to isolate, identify and extract and the phyto-constituents.
Learning outcomes	After completion of course student shall be able to know about the, ✓ different classes of phytoconstituents, their biosynthetic pathways, their properties, extraction and general process of natural product drug discovery ✓ phytochemical fingerprinting and structure elucidation of phytoconstituents.
Unit-1	Biosynthetic pathways and Radio tracing techniques: Constituents & their Biosynthesis, Isolation, Characterization and purification with a special reference to their importance in herbal industries of following phyto-pharmaceuticals containing drugs: a) Alkaloids: Ephedrine, Quinine, Strychynine, Piperine, Berberine, Taxol, Vinca alkoloids. b) Glycosides: Digitoxin, Glycyrrhizin, Sennosides, Bacosides, Quercitin. c) Steroids: Hecogenin, guggulosterone and withanolides d) Coumarin: Umbelliferone. e) Terpenoids: Cucurbitacins
Unit-2	Drug discovery and development: History of herbs as source of drugs and drug discovery, the lead structure selection process, structure development, product discovery process and drug registration, Selection and optimization of lead compounds with suitable examples from the following source : artemesin, andrographolides. Clinical studies emphasising on phases of clinical trials, protocol design for lead molecules.
Unit-3	Extraction and Phytochemical studies: Recent advances in extractions with emphasis on selection of method and choice of solvent for extraction, successive and exhaustive extraction and other methods of extraction commonly used like microwave assisted extraction, Methods of fractionation. Separation of phytoconstituents by latest CCCET, SCFE techniques including preparative HPLC and Flash column chromatography.
Unit-4	Phytochemical finger printing: HPTLC and LCMS/GCMS applications in the characterization of herbal extracts. Structure elucidation of phytoconstituents.
Unit-5	Structure elucidation of the following compounds by spectroscopic techniques like UV, IR, MS, NMR (1H, 13C) a. Carvone, Citral, Menthol b. Luteolin, Kaempferol c. Nicotine, Caffeine iv) Glycyrrhizin.

Core Course-4: Industrial Pharmacognostical Technology (MPG 104T)

Subject name and code	Industrial Pharmacognostical Technology (MPG 104T)
Scope	To understand the Industrial and commercial potential of drugs of natural origin, integrate traditional Indian systems of medicine with modern medicine and also to know regulatory and quality policy for the trade of herbals and drugs of natural origin.
Learning outcomes	By the end of the course the student shall be able to know, ✓ the requirements for setting up the herbal/natural drug industry. ✓ the guidelines for quality of herbal/natural medicines and regulatory issues. ✓ the patenting/IPR of herbals/natural drugs and trade of raw and finished materials.
Unit-1	Herbal drug industry: Infrastructure of herbal drug industry involved in production of standardized extracts and various dosage forms. Current challenges in upgrading and modernization of herbal formulations. Entrepreneurship Development, Project selection, project report, technical knowledge, Capital venture, plant design, layout and construction. Pilot plant scale-up techniques, case studies of herbal extracts. Formulation and production management of herbals.
Unit-2	Regulatory requirements for setting herbal drug industry: Global marketing management. Indian and international patent law as applicable herbal drugs and natural products. Export - Import (EXIM) policy, TRIPS. Quality assurance in herbal/natural drug products. Concepts of TQM, GMP, GLP, ISO-9000.
Unit-3	Monographs of herbal drugs: General parameters of monographs of herbal drugs and comparative study in IP, USP, Ayurvedic Pharmacopoeia, Siddha and Unani Pharmacopoeia, American herbal pharmacopoeia, British herbal pharmacopoeia, WHO guidelines in quality assessment of herbal drugs.
Unit-4	Testing of natural products and drugs: Herbal medicines - clinical laboratory testing. Stability testing of natural products, protocols.
Unit-5	Patents: Indian and international patent laws, proposed amendments as applicable to herbal/natural products and process. Geographical indication, Copyright, Patentable subject maters, novelty, non-obviousness, utility, enablement and best mode, procedure for Indian patent filing, patent processing, grant of patents, rights of patents, cases of patents, opposition and revocation of patents, patent search and literature, Controllers of patents.

Core Course-5: Pharmacognosy Practical - I (MPG 105P)

1. Analysis of Pharmacopoeial compounds of natural origin and their formulations by UV Vis spectrophotometer.
2. Analysis of recorded spectra of simple phytoconstituents.
3. Experiments based on Gas Chromatography.
4. Estimation of sodium/potassium by flame photometry.
5. Development of fingerprint of selected medicinal plant extracts commonly used in herbal drug industry viz. Ashwagandha, Tulsi, Bael, Amla, Ginger, Aloe, Vidang, Senna, Lawsonia by TLC/HPTLC method.
6. Methods of extraction.
7. Phytochemical screening.
8. Demonstration of HPLC- estimation of glycerrhizin.
9. Monograph analysis of clove oil.
10. Monograph analysis of castor oil.
11. Identification of bioactive constituents from plant extracts.
12. Formulation of different dosage forms and their standardisation.

Core Course-7: Medicinal Plant Biotechnology (MPG 201T)

Subject name and code	Medicinal Plant Biotechnology (MPG 201T)
Scope	To explore the knowledge of Biotechnology and its application in the improvement of quality of medicinal plants.
Learning outcomes	Upon completion of the course the student shall be able to: ✓ Know the process like genetic engineering in medicinal plants for higher yield of Phytopharmaceuticals. ✓ Use the biotechnological techniques for obtaining and improving the quality of natural products/medicinal plants.
Unit-1	Introduction to Plant biotechnology: Historical perspectives, prospects for development of plant biotechnology as a source of medicinal agents. Applications in pharmacy and allied fields. Genetic and molecular biology as applied to pharmacognosy, study of DNA, RNA and protein replication, genetic code, regulation of gene expression, structure and complicity of genome, cell signaling, DNA recombinant technology.
Unit-2	Different tissue culture techniques: Organogenesis and embryogenesis, synthetic seed and monoclonal variation, Protoplast fusion, Hairy root multiple shoot cultures and their applications. Micro propagation of medicinal and aromatic plants. Sterilization methods involved in tissue culture, gene transfer in plants and their applications.
Unit-3	Immobilisation techniques & Secondary Metabolite Production: Immobilization techniques of plant cell and its application on secondary metabolite .Production. Cloning of plant cell: Different methods of cloning and its applications. Advantages and disadvantages of plant cell cloning. Secondary metabolism in tissue cultures with emphasis on production of medicinal agents. Precursors and elicitors on production of secondary metabolites.
Unit-4	Biotransformation and Transgenesis: Biotransformation, bioreactors for pilot and large scale cultures of plant cells and retention of biosynthetic potential in cell culture. Transgenic plants, methods used in gene identification, localization and sequencing of genes. Application of PCR in plant genome analysis.
Unit-5	Fermentation technology: Application of Fermentation technology, Production of ergot alkaloids, single cell proteins, enzymes of pharmaceutical interest.

Core Course-8: Advanced Pharmacognosy-II (MPG 202T)

Subject name and code	Advanced Pharmacognosy-II (MPG 202T)
Scope	To know and understand the Adulteration and Deterioration that occurs in herbal/natural drugs and methods of detection of the same. Study of herbal remedies and their validations, including methods of screening.
Learning outcomes	Upon completion of the course, the student shall be able to, ✓ validation of herbal remedies ✓ methods of detection of adulteration and evaluation techniques for the herbal drugs ✓ methods of screening of herbals for various biological properties
Unit-1	Herbal remedies – Toxicity and Regulations: Herbals vs Conventional drugs, Efficacy of Herbal medicine products, Validation of herbal therapies, Pharmacodynamic and Pharmacokinetic issues.
Unit-2	Adulteration and Deterioration: Introduction, Types of Adulteration/ Substitution of Herbal drugs, Causes and Measures of Adulteration, Sampling Procedures, Determination of Foreign Matter, DNA Finger printing techniques in identification of drugs of natural origin, detection of heavy metals, pesticide residues, phytotoxin, microbial contamination in herbs and their formulations.
Unit-3	Ethnobotany and Ethnopharmacology: Ethnobotany in herbal drug evaluation, Impact of Ethnobotany in traditional medicine, New development in herbals, Bio-prospecting tools for drug discovery, Role of Ethnopharmacology in drug evaluation, Reverse Pharmacology.
Unit-4	Analytical Profiles of herbal drugs: Andrographis paniculata, Boswellia serata, Coleus forskholii, Curcuma longa, Embelica officinalis, Psoralea corylifolia.
Unit-5	Biological screening of herbal drugs: Introduction and Need for Phyto-Pharmacological Screening, New Strategies for evaluating Natural Products, In vitro evaluation techniques for Antioxidants, Antimicrobial and Anticancer drugs. In vivo evaluation techniques for Anti-inflammatory, Antiulcer, Anticancer, Wound healing, Antidiabetic, Hepatoprotective, Cardio protective, Diuretics and Antifertility, Toxicity studies as per OECD guidelines.

Core Course-9: Indian Systems of Medicine (MPG 203T)

Subject name and code	Indian Systems of Medicine (MPG 203T)
Scope	To make the students understand thoroughly the principles, preparations of medicines of various Indian systems of medicine like Ayurveda, Siddha, Homeopathy and Unani. Also focusing on clinical research of traditional medicines, quality assurance and challenges in monitoring the safety of herbal medicines.
Learning outcomes	After completion of the course, student is able to ✓ To understand the basic principles of various Indian systems of medicine. ✓ To know the clinical research of traditional medicines, Current Good Manufacturing Practice of Indian systems of medicine and their formulations.
Unit-1	Fundamental concepts of Ayurveda, Siddha, Unani and Homoeopathy systems of medicine Different dosage forms of the ISM. Ayurveda: Ayurvedic Pharmacopoeia, Analysis of formulations and bio crude drugs with references to: Identity, purity and quality. Siddha: Gunapadam (Siddha Pharmacology), raw drugs/Dhatu/Jeevam in Siddha system of medicine, Purification process (Suddhi).
Unit-2	Naturopathy, Yoga and Aromatherapy practices a) Naturopathy - Introduction, basic principles and treatment modalities. b) Yoga - Introduction and Streams of Yoga. Asanas, Pranayama, Meditations and Relaxation techniques. c) Aromatherapy – Introduction, aroma oils for common problems, carrier oils.
Unit-3	Formulation development of various systems of medicine Salient features of the techniques of preparation of some of the important class of Formulations as per Ayurveda, Siddha, Homeopathy and Unani Pharmacopoeia and texts. Standardization, Shelf life and Stability studies of ISM formulations.
Unit-4	Schedule T – Good Manufacturing Practice of Indian systems of medicine. Components of GMP (Schedule – T) and its objectives, Infrastructural requirements, working space, storage area, machinery and equipments, standard operating procedures, health and hygiene, documentation and records. Quality assurance in ISM formulation industry - GAP, GMP and GLP. Preparation of documents for new drug application and export registration. Challenges in monitoring the safety of herbal medicines: Regulation, quality assurance and control, National/Regional Pharmacopoeias.
Unit-5	TKDL, Geographical indication Bill, Government bills in AYUSH, ISM, CCRAS, CCRS, CCRH, CCRU.

Core Course-10: Herbal Cosmetics (MPG 204T)

Subject name and code	Herbal Cosmetics (MPG 204T)
Scope	This subject deals with the study of preparation and standardization of herbal/natural cosmetics. This subject gives emphasis to various national and international standards prescribed regarding herbal cosmeceuticals.
Learning outcomes	After completion of the course, the student shall be able to, ✓ understand the basic principles of various herbal/natural cosmetic preparations. ✓ current Good Manufacturing Practices of herbal/natural cosmetics as per the regulatory authorities.
Unit-1	Introduction: Herbal/natural cosmetics, Classification & Economic aspects. Regulatory Provisions relation to manufacture of cosmetics: - License, GMP, offences & Penalties, Import & Export of Herbal/natural cosmetics, Industries involved in the production of Herbal/natural cosmetics.
Unit-2	Commonly used herbal cosmetics, raw materials, preservatives, surfactants, humectants, oils, colors, and some functional herbs, preformulation studies, compatibility studies, possible interactions between chemicals and herbs, design of herbal cosmetic formulation.
Unit-3	Herbal Cosmetics: Physiology and chemistry of skin and pigmentation, hairs, scalp, lips and nail, Cleansing cream, Lotions, Face powders, Face packs, Lipsticks, Bath products, soaps and baby product. Preparation and standardisation of the following: Tonic, Bleaches, Dentifrices and Mouth washes & Tooth Pastes, Cosmetics for Nails.
Unit-4	Cosmeceuticals of herbal and natural origin: Hair growth formulations, Shampoos, Conditioners, Colorants & hair oils, Fairness formulations, vanishing & foundation creams, anti-sun burn preparations, moisturizing creams, deodorants.
Unit-5	Analysis of Cosmetics, Toxicity screening and test methods: Quality control and toxicity studies as per Drug and Cosmetics Act.

Core Course-11: Pharmacognosy Practical-II (MPG 205P)

1. Isolation of nucleic acid from cauliflower heads. 2. Isolation of RNA from yeast. 3. Quantitative estimation of DNA. 4. Immobilization technique. 5. Establishment of callus culture. 6. Establishment of suspension culture. 7. Estimation of aldehyde contents of volatile oils. 8. Estimation of total phenolic content in herbal raw materials. 9. Estimation of total alkaloid content in herbal raw materials. 10. Estimation of total flavonoid content in herbal raw materials. 11. Preparation and standardization of various simple dosage forms from Ayurvedic, Siddha, Homoeopathy and Unani formulary. 12. Preparation of certain Aromatherapy formulations. 13. Preparation of herbal cosmetic formulation such as lip balm, lipstick, facial cream, herbal hair and nail care products. 14. Evaluation of herbal tablets and capsules. 15. Preparation of sunscreen, UV protection cream, skin care formulations. 16. Formulation & standardization of herbal cough syrup.

Core Course-13: Research Methodology & Biostatistics (MPG 301T)

Subject name and code	Research Methodology & Biostatistics (MPG 301T)
Unit-1	General Research Methodology: Research, objective, requirements, practical difficulties, review of literature, study design, types of studies, strategies to eliminate errors/bias, controls, randomization, crossover design, placebo, blinding techniques.
Unit-2	Biostatistics: Definition, application, sample size, importance of sample size, factors influencing sample size, dropouts, statistical tests of significance, type of significance tests, parametric tests (students "t" test, ANOVA, Correlation coefficient, regression), non-parametric tests (wilcoxan rank tests, analysis of variance, correlation, chi square test), null hypothesis, P values, degree of freedom, interpretation of P values.
Unit-3	Medical Research: History, values in medical ethics, autonomy, beneficence, non-maleficence, double effect, conflicts between autonomy and beneficence/non-maleficence, euthanasia, informed consent, confidentiality, criticisms of orthodox medical ethics, importance of communication, control resolution, guidelines, ethics committees, cultural concerns, truth telling, online business practices, conflicts of interest, referral, vendor relationships, treatment of family members, sexual relationships, fatality.
Unit-4	CPCSEA guidelines for laboratory animal facility: Goals, veterinary care, quarantine, surveillance, diagnosis, treatment and control of disease, personal hygiene, location of animal facilities to laboratories, anesthesia, euthanasia, physical facilities, environment, animal husbandry, record keeping, SOPs, personnel and training, transport of lab animals.
Unit-5	Declaration of Helsinki: History, introduction, basic principles for all medical research, and additional principles for medical research combined with medical care.

9.2. Elective Courses for other Departments

GEC-1: Traditional Medicines **Course Code: SIAS PS 03 01 01 E 4004**

Subject name	Traditional Medicines
Scope	The subject will impart advanced knowledge about the role of traditional medicines in healthcare
Learning outcomes	The students shall be able to learn the ✓ Alternative systems of Medicines ✓ Basic principles, theory and methods of traditional systems of medicines ✓ Various dosage forms used in traditional systems of medicines
Unit-1	Introduction and basic principles of Ayurvedic system of Medicine. Different dosage forms employed in Ayurveda.
Unit-2	Introduction and basic principles of Homeopathy system of Medicine. Formulations employed in Homeopathy
Unit-3	Aromatherapy: Introduction, aroma oils for common problems, carrier oils.
Unit-4	Good Manufacturing Practice (GMP)/Schedule-T of Ayurvedic and Homeopathic system of Medicine.

GEC-2: Herbal Pharmacotherapy **Course Code: SIAS PS 03 02 01 E 4004**

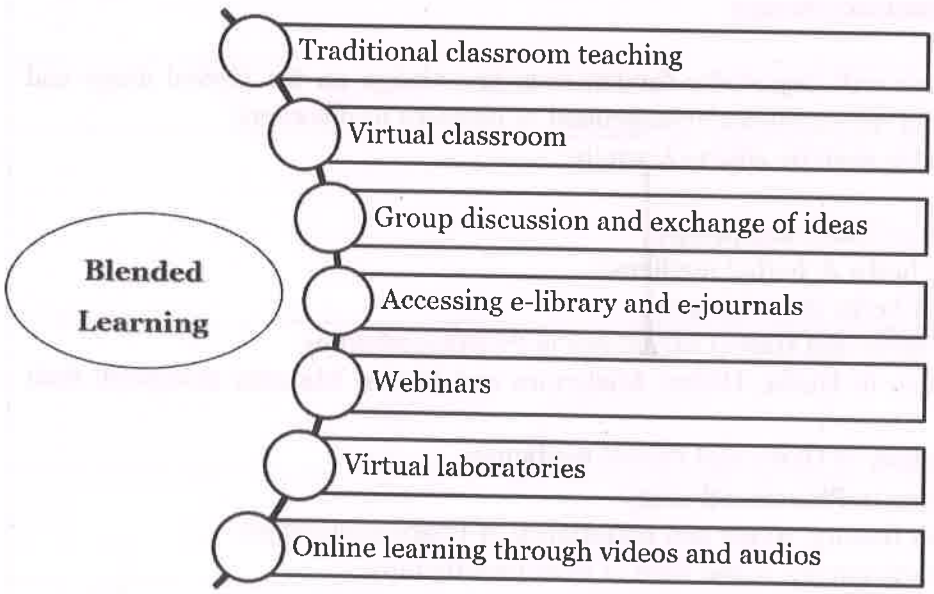
Subject name	Herbal Pharmacotherapy
Scope	The subject will impart the fundamental knowledge on the Herbal drugs and their role in the treatment/management of diseases or disorders.
Learning outcomes	The students shall be able to learn the ✓ Basics of Pharmacotherapy ✓ About herbs & herbal medicines ✓ Role of herbs in healthcare
Unit-1	Need of Herbs and Herbal Medicines in Pharmacotherapy. Introduction to Herbs, Herbal Medicines and Herbal Material alongwith their sources; Classification of Herbs and Herbal medicines.
Unit-2	Introduction to Pharmacotherapy: Definition, history, scope and importance of Pharmacotherapy. Recent development in the field of Pharmacotherapy
Unit-3	Pharmacotherapy for the treatment/management of Diabetes, Cancer, Obesity, skin and hair diseases
Unit-4	Role of Pharmacotherapy in day to day life. Role of healthcare professionals in promoting herbal Pharmacotherapy. Recent opportunities and Challenges in Herbal Pharmacotherapy

10.Teaching-Learning Process

1. Classroom Lectures
2. Interactive sessions
3. Animation and videos demonstration
4. Quizzes
5. Flipped classroom
6. Group discussions
7. Seminars
8. Electronic learning
9. Tutorials
10. Laboratory demonstrations
11. Collaborative Learning
12. Self-assessed or peer-assessed assignments

11.Blended Learning

A concept that includes framing teaching learning process and incorporates both face to face teaching and teaching supported by ICT. Blended learning incorporates direct as well as indirect instruction, collaborative teaching learning, and individualized computer-assisted learning.



12. Assessment and Evaluation

Internal assessment: Continuous mode

Subject type	Criteria	Maximum Marks
Theory	Attendance	8
	Student – Teacher interaction	2
	Total	**10**
Practical	Attendance	10
	Based on Practical Records, Regular viva voce, etc.	10
	Total	**20**

Scheme for awarding internal assessment: Continuous mode

Guidelines for the allotment of marks for attendance

Percentage of Attendance	Theory	Practical
95 – 100	8	10
90 – 94	6	7.5
85 – 89	4	5
80 – 84	2	2.5
Less than 80	0	0

- Mid-semester and Comprehensive End-term Examination of courses
- Continuous evaluation in the form of
    - ✓ Class work,
    - ✓ Check-in assessment
    - ✓ Periodical quizzes,
    - ✓ Group discussions
    - ✓ Surprise tests,
    - ✓ Tutorials,
    - ✓ Laboratory work evaluation
- Collaborative Assignments
- Open book learning to assess problem solving and analytical abilities
- Oral presentations
- Multiple choice examination
- Problem solving exercises in groups

13.Keywords

- NEP-2020
- Blended Learning
- Programme Educational Objectives (PEOs)
- Learning Outcomes
- Programme Outcomes
- Postgraduate Attributes
- Continuous Mode
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Learning Outcome Index
- Teaching-Learning Process

14.References

1. National Education Policy-2020.https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
2. Pharmacy council of India, M. Pharm Syllabus https://www.pci.nic.in/pdf/Syllabus_M_Pharm.pdf
3. Blended Mode of Teaching and Learning: Concept Note. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

ज्ञान-विज्ञान विमुक्तये

प्रो. रजनीश जैन
सचिव

Prof. Rajnish Jain
Secretary

सत्यमेव जयते

विश्वविद्यालय अनुदान आयोग
University Grants Commission
(शिक्षा मंत्रालय, भारत सरकार)
(Ministry of Education, Govt. of India)
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D.O.No.4-6 / 2020(NSQF)

7th December, 2020

Subject: UGC Guidelines for Higher Education Institutions to offer Apprenticeship/Internship embedded Degree Programme

Madam / Sir,

As you are aware, in order to capitalise on India's remarkable demographic dividend, it is essential not only to improve the quality of education but also to make it relevant in terms of providing employment opportunities. The competencies demanded by the industry need to be embedded in our university curriculum so that the employment-employability gap is overcome. The minimal linkage between the general degree curriculum and employer's requirement calls for an effective remodeling of degree programmes, driven by changing needs of the industry and service sector. Apprenticeship and internship can play a significant role in this context. World over, apprenticeship is considered as the most efficient and promising structured training for exposure to the real working environment. Realising the importance of apprenticeship/internship, the Budget announcement of 2020-21 set out for the introduction of Apprenticeship Embedded Degree/Diploma Programme to improve employability of general stream students.

In line with the Budget Announcement and with the objective of making the fresh graduates employment-ready with necessary knowledge, competencies and attitude, Hon'ble Education Minister, Government of India recently launched the **UGC Guidelines for Higher Education Institutions to offer Apprenticeship/Internship embedded Degree Programme** for embedding apprenticeship/internship in general degree programmes offered by the Universities. A copy of the Guidelines is attached herewith. Considering the interests of the students and society at large, you are requested to kindly promote apprenticeship/internship embedded degree programmes in your University as well as the colleges/institutions affiliated to your University.

With kind regards,

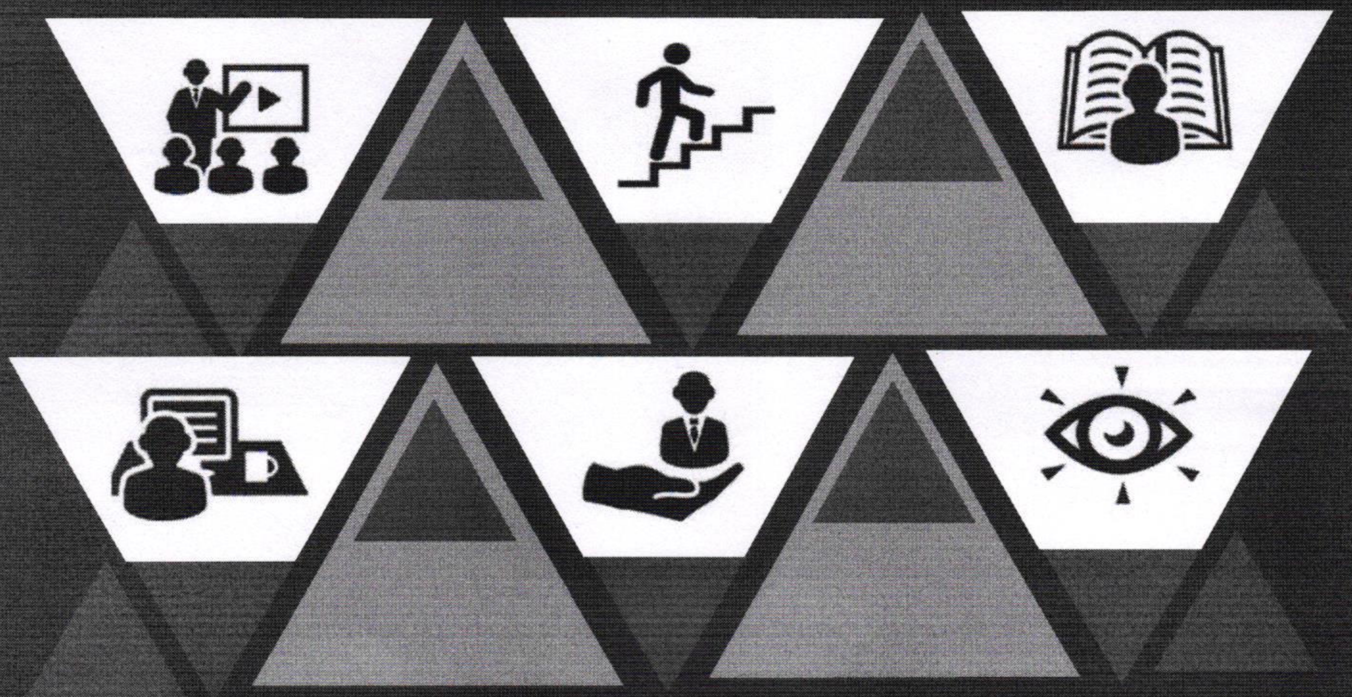
Yours sincerely,

(Rajnish Jain)

To:

The Vice-Chancellors of all Universities

UGC Guidelines for Higher Education Institutions to offer Apprenticeship/Internship embedded Degree Programme



University Grants Commission
Bahadur Shah Zafar Marg
New Delhi

JULY, 2020

सत्यमेव जयते

ज्ञान-विज्ञान विमुक्तये

UGC Guidelines for
Higher Education Institutions to offer
Apprenticeship/Internship embedded Degree Programme

ज्ञान-विज्ञान विमुक्तये

University Grants Commission
Bahadur Shah Zafar Marg
New Delhi

July, 2020

July, 2020

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FOREWORD

ज्ञान-विज्ञान विमुक्तये

India is going to have the largest working age population in the world by 2030, but gainful employment for general stream students is a major challenge. Improving employability of these students requires a new vision with curricular support for employment. Apprenticeship/Internship has a prominent role to play in linking higher education with the requirements of the industry and the world of work. This is considered to be one of the most effective ways to develop skilled manpower for the country. It provides for an industry led, practice oriented and outcome based learning.

Striving to fulfil this objective of improving employability and forming robust industry-academia linkage, the UGC has framed **Guidelines for Higher Education Institutions to offer Apprenticeship/Internship embedded Degree Programme.** The UGC Guidelines will provide an option for Higher Educational Institutions to embed Apprenticeship/Internship in any UG degree programmes specified by UGC. This will focus on outcome-based learning in degree programme and will enable students to demonstrate workforce professional abilities for potential employment.

With a matter of great pride and privilege, I am sharing these guidelines and hope that this will give the much needed impetus to overcome the Employment-Employability gap. I take this opportunity to record my sincere thanks and gratitude to Prof Rajnish Jain, Secretary, UGC, Shri Madhu Ranjan Kumar, JS, MHRD & Dr. Manju Singh, JS, UGC for developing these guidelines.

I would urge upon all Universities/Colleges to come forward and take measures to introduce Apprenticeship/Internship embedded Degree Programme in the larger interest of our students.

DPSingh

24th July, 2020
New Delhi

(Prof. D.P Singh)
Chairman
University Grants Commission

INDEX

ज्ञान-विज्ञान विमुक्तये

I. PREAMBLE

ज्ञान-विज्ञान विमुक्तये

India is going to have the largest working age population in the world by 2030. To capitalise on India's remarkable demographic dividend, it is essential not only to improve the quality of education but also to make it relevant in terms of providing employment opportunities. Aligned with the Sustainable Development Goals (SDGs), the Government of India has undertaken various initiatives to enable youth to fully participate in the job market and gain access to employment services. Despite this, gainful employment is a challenge for most of the graduating students from our universities. Particularly, when we consider this for the general stream students, limited employment for graduating student is a major challenge. The primary factor responsible for this phenomenon is "being non-employable". Therefore, there is a need to bridge the disconnect between 'what is taught in the class' and 'what is required by the society'. The competencies demanded by the industry need to be embedded in our university curriculum so that the Employment-Employability gap is overcome.

The education system has to be tailor-made to suit the requirements of the society at large and the economy in particular. Further, with a large number of students enrolled in general degree programmes in India every year, there is a consensus among stakeholders for shift from "academic only" approach. The minimal linkage between the general degree curriculum and employer's requirement calls for an effective remodeling of degree programmes, driven by changing needs of the industry and service sector. This remodelling in turn needs a robust institutionalised framework for industry-academia linkage to increase the employability of the students.

Apprenticeship and internship have a huge role to play in this context. World over, apprenticeship is considered as the most efficient and promising structured training for exposure to the real working environment. This has enormous potential to combine work-based learning with theoretical knowledge of related disciplines. Through apprenticeship/internship, students may actively engage with the practical side of their learning like problem-solving, creative thinking, digital skills, teamwork etc. This apprenticeship/internship experience will augment the employability of students in the general stream substantially and will also forge a close functional link between education and industry/service sectors on a sustainable basis apart from helping the industry securing good quality manpower. Realising this need, the Budget announcement of 2020-21 set out for the introduction of Apprenticeship Embedded Degree/Diploma Programme to improve employability of general stream students.

Amendments made to Apprenticeship Act and Apprenticeship Rules during 2014 to 2019 have opened the prospect of linking apprenticeship programme to education. The extant provisions enable non-engineering graduates, fresh non-graduates without any prior skill training, and students undergoing training as an integrated component of the curricula to undergo apprenticeship training for a minimum of six months to a maximum of three years. The flexible curricular structure will create new possibilities for outcome-based learning and facilitate graduation degree described in terms of such learning outcomes.

Accordingly, with the objective of making the fresh graduates employment-ready with necessary knowledge, competencies and attitude, UGC has formulated these **Guidelines for Higher Education Institutions to offer Apprenticeship/Internship embedded Degree Programme** for embedding apprenticeship/internship in general degree programmes offered by the Universities. These guidelines will enable the apprenticeship/internship embedded Degree programme in general stream with cooperation between Industry and Academia.

II. OBJECTIVES

1. To improve the employability of students pursuing Undergraduate level general degree Programme.

2. To focus on outcome-based learning in degree programmes.

3. To promote active linkage between the higher education system and industry, non-commercial and commercial enterprises/organisations.

III. SCOPE

GENERAL PROVISIONS

1. Any UG degree programme in all disciplines as specified by the UGC under section 22 (3) of the UGC Act, 1956 is eligible to embed apprenticeship/ internshipin to the degree programme.
2. An apprenticeship/internship embedded degree programme shall be treated at par with the UG degree programmes specified by the UGC under section 22 (3) of the UGC Act, 1956.
3. Students graduating from the apprenticeship/internship embedded degree programme shall be eligible to take admission in the Master's programme in the specific subject in which they have earned their undergraduate degree (i.e. bachelor degree) as well as in subject(s) for which they have taken 24 credits in the core subjects as a part of their undergraduate programme (see para 18 and para 19 for details). Such students shall also be considered eligible for transdisciplinary vertical mobility into such courses where entry qualification is a Bachelor Degree without specific requirements in a particular discipline.
4. The HEIs in consultation with Sector Skill Councils, AICTE, FICCI, CII, commercial and non-commercial organizations or enterprises, and industry would design the apprenticeship/internship embedded degree programme in a way consistent with these guidelines.
5. Embedding apprenticeship/internship will offer a kind of a traineeship which shall be undertaken not on the campus but at the premises of the workplace like commercial or non-commercial organizations or enterprises, or offices, or industry, or industry associations to get work-based learning in identified discipline/trade.
6. The HEIs should have a prior Memorandum of Understanding (MoU) with discipline specific commercial and non-commercial organizations or enterprises, offices, industry etc. for providing apprenticeship/internship, before introducing the apprenticeship/internship embedded degree programme.
7. The HEIs may plan the number of seats for apprenticeship/internship training as per the facility and infrastructure available.

DURATION

8. Any UG degree programme will have an option to embed at least one semester of apprenticeship/internship as part of the degree programme without altering the total duration of the programme.
9. The period of apprenticeship/internship training shall be decided on the basis of individual requirements of course concerned.
10. The HEIs shall have the flexibility to schedule apprenticeship/internship within the course duration.
11. The spells of apprenticeship/internship shall be scheduled either continuously or at intervals depending upon the requirement and practicality of the discipline concerned.

CREDIT MECHANISM

12. Credits for apprenticeship/internship programme shall be included in the total credits of the entire programme.
13. The total credits assigned to a particular degree programme shall continue to follow the CBCS. Accordingly, a student will have to earn 132 credits for the award of undergraduate degree. Credits for apprenticeship/ internship training may be suitably accommodated in the Choice Based Credit System (CBCS) by the HEI.
14. At least 20% of the total Credits for the degree programme should be assigned to apprenticeship/internship.
15. The HEIs may evolve its own mechanism to give academic credits for the apprenticeship/internship undergone as part of the programme.
16. In case of HEIs still following the annual system, suitable provisions may be introduced accordingly. Apprenticeship/internship training may be introduced in lieu /addition of the courses of the degree programme by assigning due weightage corresponding to the period of apprenticeship/ internship done.
17. Apprenticeship/internship training should be assigned in the specific domain areas of their coursework. National Occupation Standards (NOS) can be one approach to align the courses and curriculum to the standards set by the industry. If required, relevant course/s may be introduced/realigned to provide basic knowledge/training in the area of apprenticeship/internship.
18. As per CBCS guidelines, *wherever a University requires that an applicant for a particular M.A/M.Sc./Technical/Professional course should have studied a specific discipline at the Undergraduate level, it is suggested that obtaining 24 credits in the concerned discipline at the undergraduate level may be deemed to be considered sufficient to satisfy such a requirement for admission to the M.A./M.Sc./Technical/Professional course.*

19. Accordingly, in the apprenticeship/internship embedded degree programme, if a student has done 24 credits as a core course which also forms part of the core course in a concerned discipline of CBCS at the undergraduate level, the student will be considered eligible for admission in that CBCS discipline in the M.A./M.Sc/Technical/Professional programme e.g. a student who has done BBA (logistics apprenticeship) with 24 credits in Economics, the student will be eligible to apply for MA/M.Sc. course in Economics.

20. Hence HEIs will have to ensure that in the apprenticeship/internship embedded degree programme, at least 24 credits are being offered as core course which otherwise form a part of a regular undergraduate programme within the CBCS e.g. a BBA (Logistics - apprenticeship/ internship) will necessarily have 24 credits (within its 12 core papers) from a subject area - say BA(Economic) or BA (Vocational Studies-Materials Management) - which are there in the UGC list of Bachelor courses in CBCS. This will ensure vertical mobility to the student to a post graduate programme.

ASSESSMENT

21. Institutions may opt for any mechanism for the apprenticeship/ internship assessment in consultation with commercial or non-commercial organisations or enterprises, or offices, or industry, or industry associations, or sector skill councils where the apprenticeship/internship is proposed to be imparted. The apprenticeship/internship can also be done within the ambit of National Apprenticeship Training Scheme (NATS) operated by Bureau of Apprenticeship Training (BOAT) under MHRD.

22. Accordingly, evaluation of apprenticeship/internship can be done by commercial or non-commercial organizations or enterprises, or offices, or industry, or industry associations, or sector skill councils where the apprenticeship is proposed to be imparted and by the faculty of the institutions.

23. The students may be assigned grades/marks corresponding to the credits earned as per CBCS guidelines. In case of Institutions still following annual pattern, marks may be assigned to the students.

24. The students must pass the apprenticeship/internship course. Reappearance for failed/uncompleted apprenticeship/internship training is mandatory.

25. The marks secured by the student in apprenticeship/internship course will be reflected in the semester and final grade sheet.

LEARNING OUTCOME

26. The underlying premise of the learning outcome-based approach to curriculum planning and development is that, higher education qualification such as a Bachelor's Degree is awarded on the basis of demonstrated achievement of outcomes (expressed in terms of knowledge, understanding skills, attitudes and values) and on the basis of demonstrated achievement of academic standards (expected of graduates of a programme of study).
27. UGC through the Learning Outcome based Curriculum Framework (LOCF) provides for flexibility and innovation in programme design and syllabus development by HEIs.
28. HEIs offering apprenticeship/internship-embedded degree programme should develop and maintain domain specific Learning Outcomes for the Apprenticeship/Internship Programme.
29. Apprenticeship/internship learning outcomes will focus on knowledge and abilities that prepare students for potential employment.
30. This will enable students to demonstrate workforce professional abilities within the required domain of their chosen subject.

IV. ROLE OF THE HIGHER EDUCATION INSTITUTIONS

The HEIs are encouraged to offer the Apprenticeship/Internship embedded Degree Programme to the students. HEIs will make the students aware about the programme along with its merits to motivate them to opt for apprenticeship/internship embedded Degree Programme and elicit their interest in participation. The HEIs in consultation with Sector Skill Councils and/or industry/industry associations and/or commercial/non-commercial organisations/enterprises and/or offices, would design the Apprenticeship/Internship embedded Degree Programme in a way consistent with these guidelines. The HEIs shall have an Apprenticeship Cell with an overall role of a facilitator and counsellor for apprenticeship/internship related activities. The HEIs concerned must obtain the approval from their respective Academic/Executive Bodies as required by their Statutes. This programme will benefit the HEIs in

- Promoting Industry-Academia linkages
- Improving Institution's credibility and in brand building
- Improving the teaching learning process
- Functioning of the placement cell

V. ROLE OF INDUSTRY ASSOCIATIONS, SSC AND BOAT

ज्ञान-विज्ञान विमुक्तये

- The industry associations like FICCI, CII, commercial and non-commercial organizations or enterprises and industry would assist the HEIs in designing the apprenticeship/internship embedded Degree Programme.
- Sector Skill Councils (SSC) and Board of Apprenticeship Training (BOAT) will play an important role in helping the HEIs in identifying industries for apprenticeship/internship.
- The SSC and BOAT can also assist the HEIs in designing the apprenticeship/internship embedded Degree Programme in a way consistent with these guidelines.

VI. MONITORING BY UGC

- UGC will maintain a dedicated portal for obtaining relevant information from the HEIs.
- Institutions offering Apprenticeship/Internship-embedded Degree Programme will be required to submit details regarding the programme/s on the aforesaid portal.

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website: www.ugc.ac.in

ज्ञान-विज्ञान विमुक्तये

Annexure-XXIII

विश्वविद्यालय अनुदान आयोग
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सत्यमेव जयते

प्रो. रजनीश जैन
सचिव
Prof. Rajnish Jain
Secretary

D.O.F.No. 9-1/2010 (PS/Misc)PT-I

30th September,2022

30 SEP 2022

Subject: Guidelines for engaging Professor of Practice in Universities and Colleges.

Respected Madam/Sir,

In the context of holistic and multidisciplinary education, as recommended in the NEP 2020, it is important for the Higher Education Institutions (HEIs) to address the capacity constraints, especially with reference to integration of general education with vocational education. Realizing that the HEIs need people with skills and expertise acquired in non-academic careers, in teaching and research, the UGC has taken a new initiative of engaging Professor of Practice in HEIs. Please find enclosed the guidelines for engaging Professor of Practice in Universities and Colleges.

Vice Chancellors of Universities and Principals of Colleges are requested to take necessary steps to engage Professor of Practice according to the requirement and by following the enclosed guidelines.

With kind regards,

Yours sincerely,

(Rajnish Jain)

Encl: as above

To

1. The Vice-Chancellors / Directors of all Universities/Institutions
2. The Principals of all Colleges

Guidelines for Engaging Professor of Practice in Universities and Colleges

The National Education Policy 2020 seeks to transform higher education by focusing on skill- based education to meet needs of the industry and the economy. Further, the NEP also recommends integrating vocational education with general education and strengthening industry-academia collaboration in HEIs. For skilling of youth at the optimum level, learners are required to think like employers and employers are to think like learners. Towards this, the UGC has taken a new initiative to bring the industry and other professional expertise into the academic institutions through a new category of positions called "Professor of Practice". This will help to take real world practices and experiences into the class rooms and also augment the faculty resources in higher education institutions. In turn, the industry and society will benefit from trained graduates equipped with the relevant skills.

1. Objectives:

i. To develop courses and curriculum to meet the industry and societal needs and enable the HEIs to work with industry experts on joint research projects and consultancy services which will be mutually beneficial;

ii. To bring in distinguished experts from various fields such as engineering, science, technology, entrepreneurship, management, chartered accountancy (CA), commerce, social sciences, media, literature, fine arts, civil services, armed forces, legal profession and public administration into the academic institutions;

iii. To enable the higher education institutions to formally associate with persons of eminence and encourage them to participate in experiential learning, research, training, skilling, entrepreneurship and extension and to play mentoring role.

2. Eligibility:

i. Distinguished experts who have made remarkable contributions in their professions from various fields such as engineering, science, technology, entrepreneurship, commerce, social sciences, media, literature, fine arts, civil services, armed forces, legal profession, community development, panchayati raj, rural development, watershed development, water-harvesting, organic farming, small green energy systems, municipal planning, community participation, gender budgeting/planning, inclusive development of tribals and public administration among others. Those who have proven expertise in their specific profession or role with at least 15 years of service/experience, preferably at a senior level, will be eligible for Professor of Practice.

ii. A formal academic qualification is not considered essential for this position if they have exemplary professional practice in lieu. These experts will also be exempted from the requirement of publications and other eligibility criteria stipulated for the recruitment of faculty members at the Professor level. However, they should possess the skills to carry out the duties and responsibilities specified in the following section.

iii. The number of Professors of Practice in a HEI, at any point in time, should not exceed 10% of the sanctioned posts in a HEI.

3. Duties and Responsibilities:

i. Involve in the development and designing of courses and curriculum.

ii. Introduce new courses and deliver lectures as per institutional policies.

iii. To encourage students in innovation and entrepreneurship projects & provide necessary mentorship for these activities.

iv. To focus on enhanced industry-academia collaborations.

v. Conduct jointly in collaboration with regular faculty member of the institution, workshops, seminars, deliver special lectures and training programmes.

vi. Carryout joint research project or consultancy services in collaboration with the regular faculty member of the concerned HEI.

4. General Conditions:

i. The engagement of Professor of Practice will be for a fixed term.
ii. The engagement of Professor of Practice will be exclusive of the sanctioned posts of a university/college. It will not affect the number of sanctioned posts and the recruitment of regular faculty members.
iii. Professor of Practice is not open for those in teaching profession- serving or retired.

5. Categories of Engagement:

It is envisioned that Professor of Practice can be engaged in one of the followingcategories:

A. Professor of Practice funded by Industries
B. Professor of Practice funded by HEIs from their own resources
C. Professor of Practice on Honorary basis

A. Professor of Practice funded by Industries:

Today’s industry looks for graduates with specific skill sets. But the higher education system is churning out graduates who fall short of the required skills. As a result, many industries now hire graduates and provide adequate training before employing them. Involving experts from industry in teaching will benefit both the industry and the higher educational institutions. For engaging industry experts and professionals in this category, HEIs may collaborate with the industries to support the Professor of Practice positions.

B. Professor of Practice funded by HEIs from their own resources:

As per the policy directives of NEP 2020, graduate programmes are revised with the holistic and multidisciplinary approach. HEIs may assess the required gap areas in different fields and engage experts working in leadership positions in various fields. In this category, the remuneration for the Professor of Practice is made by HEIs from their own resources as indicated below:

Remuneration:

Part-time/Full-time engagement: Consolidated amount, mutually agreed between the institution and expert.

C. Professor of Practice on Honorary basis:

Experts fulfilling the eligibility criteria for the Professor of Practice may like to share their expertise with students and come forward to teach on honorary basis. Such experts may be engaged on honorary basis as Professor of Practice and their services may be utilized for the benefit of the students.

The HEIs may decide on the amount of honorarium to be paid to the Professor of Practice in this category from their own resources.

6. Procedure for selecting Professor of Practice

a) The Vice-Chancellors/Directors may invite nominations from eminent experts for Professor of Practice positions.
b) The experts willing to serve may also be nominated or they can send their nomination to the Vice-Chancellor/Director with a detailed biodata and a brief write-up about their potential contribution to the HEI.
c) Such nominations will be considered by a selection committee consisting of two senior Professors from the HEI and one eminent external member. Based on the recommendations of this committee, the Academic Council and the Executive Council or statutory bodies of the HEI will decide on the engagement.

7. Tenure

The engagement may be initially for up to one year. At the end of the initial engagement or subsequent extension, the HEI will make an assessment and take the decision about extension. The HEI will devise its own assessment procedure for extension based on the contribution and requirement of the experts engaged as Professors of Practice.

The maximum duration of service of Professor of Practice at a given institution should not exceed three years and is extendable by one year in exceptional cases and the total service should not exceed four years under any circumstances.

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ज्ञान-विज्ञान विमुक्तये

प्रो. रजनीश जैन
सचिव

Prof. Rajnish Jain
Secretary

सत्यमेव जयते

विश्वविद्यालय अनुदान आयोग
University Grants Commission
(शिक्षा मंत्रालय, भारत सरकार)
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D.O. No. 1-1/2022(CPP-II) **30 September, 2022**

Subject: Guidelines for Admission and Supernumerary seats of International Students in Undergraduate and Postgraduate Programmes in Higher Educational Institutions in India

Respected Madam / Sir,

As you are aware, UGC had issued Guidelines for Internationalisation of Higher Education in India on 29thJuly 2021 which enumerates various strategies and initiatives and provide an excellent opportunity through a wide array of activities for global outreach of Indian Higher Education institutions. Internationalisation of higher education is an essential aspect of the National Education Policy 2020.

Opportunities to attract international students, academics and funding are growing and many Indian Higher Educational Institutions (HEIs) are now committed to increase their international outreach. In order to facilitate the internationalisation of Indian HEIs, the University Grants Commission has framed the guidelines for admission and creation of supernumerary seats for international students with an objective to facilitate smooth and simple admission of international students in higher educational institutions of India, to create a favourable environment for attracting international students to Indian higher education system and to make India a preferred destination for international students.

All Higher Educational Institutions and its affiliated colleges / institutions are requested to adopt and implement the above said guidelines for admission and Supernumerary seats of international students in a transparent manner. A copy of the guidelines is attached herewith.

With kind regards,

Yours sincerely,

(Rajnish Jain)

Encl: As above.

To
The Vice Chancellors of all Universities
Principals / Directors of all Colleges /Institutions

ज्ञान-विज्ञानं विमुक्तये

UNIVERSITY GRANTS COMMISSION

Guidelines for Admission and Supernumerary seats of International Students in Undergraduate and Postgraduate Programmes in Higher Educational Institutions in India

Introduction

The National Education Policy (NEP) 2020 envisages a new and forward-looking vision for India's higher education system. It sets the foundation for the much-needed transformation and overhaul of the current education system through its focus on key issues like access, equity, multidisciplinarity, holistic and value-based education. The Indian higher education system is one of the world's largest systems and transformation of such a vast system requires transforming the system or processes for all Higher Education spheres including areas of leadership, funding, quality of education delivery, accountability, management, teaching-learning & research, as well as internationalization.

Internationalisation of higher education is an essential aspect of the National Education Policy 2020. The need to internationalise certain aspects of higher education, while making all higher education relevant internationally has been a major area of focus. Internationalisation of higher education is the process of integrating an international and intercultural dimension in higher education. Opportunities to attract international students, academics and funding are growing and many Indian Higher Educational Institutions (HEIs) are now committed to increase their international outreach. In order to facilitate the internationalisation of Indian HEIs, the University Grants Commission has framed the guidelines for admission and creation of supernumerary seats for international students.

Objectives

1. To facilitate a smooth and simple admission of international students in higher educational institutions of India.

2. To create a favourable environment for attracting international students to Indian higher education system.

3. To make India a preferred destination for international students.

GUIDELINES

1. Indian HEIs may admit international students based on the equivalence of entry qualification held by them. The equivalence is to be determined by the University Grants Commission (UGC) or any other body recognised by UGC for such purpose or

the concerned regulatory bodies of the country. HEIs may adopt a transparent admission process for admitting the international students.

2. HEIs may create up to 25% supernumerary seats for international students, over and above of their total sanctioned enrolment for Undergraduate and Postgraduate programmes. The decision regarding 25% supernumerary seats has to be carried out by the concerned higher educational institutions as per specific guidelines/regulations issued by the regulatory bodies considering the infrastructure, faculty and other requirements.

3 The 25% of the supernumerary seats for international students will not include the international students under exchange programmes or/and through Memorandum of Understanding (MoU) between institutions or between Government of India and other countries.

4 Depending on the availability of infrastructure and qualified faculty, efforts should be made to distribute these 25% seats among all departments, schools, centres or any other academic unit of the higher educational institution, wherever possible.

5 The supernumerary seats shall be exclusively meant for the international students both in the Undergraduate and Post-graduate programmes. A seat remained unfilled in the supernumerary category, shall not be allocated to anyone other than an international student. International students in this context shall be defined as the one who shall possess a foreign passport.

6 The provision of creating supernumerary seats for international students should be formalized by way of approval of statutory body/bodies of the HEIs in accordance with the guidelines/regulations issued by the regulatory bodies from time to time.

7 The supernumerary seats in professional and technical institutes shall be governed by the respective statutory bodies.

8 Supernumerary seats for Ph.D. programmes shall be governed by the Regulations notified by the University Grants Commission from time to time in this regard.

9 All HEIs shall have an 'Office for International Students'. Year-wise details, i.e., country, number, programme/subject, duration etc., regarding the international students in the HEI be maintained by it and be made available on their website.

10 All details regarding number of seats available for international students in each programme, fee prescribed for the same, admission process, eligibility conditions etc. shall be made available on the website of the HEI.

11 All existing rules/provisions notified by Government of India regarding visa/ Foreign Regional Registration Offices (FRRO) etc. shall be followed by the HEIs.

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भारतीय विधिज्ञ परिषद्
BAR COUNCIL OF INDIA

(Statutory Body Constituted under the Advocates Act, 1961)

21, Rouse Avenue Institutional Area, Near Bal Bhawan, New Delhi - 110002

BCI:D 1453 /2022 :LE:BCI Dated: 03.10.2022

To,

Dean,
School of Law,
Central University off Haryana,
Mahendragarh,
Haryana

Sub.: Balance regularization fee.

Ref.: 1. Your letter No. CUH/345 dated 03.10.2022.
2. Our letter No. BCI/D/1386/2022 dated 29.09.2022.

Sir,

With reference to your abovementioned letter, it is to inform you that you are required to deposit balance regularization fee of Rs. 50,000/-.

Once you deposit the balance fee, the regularization of the students of second section of three year LL.B course for the academic year 2020-21 shall stand regularized.

Thanking you,

Yours sincerely,

Ashok K. Pandey,
Joint Secretary