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 :	05.07.2023	18.07.2023	

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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) (All courses are compulsory)	Generic Elective (GE) each with 06 (4+2) 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 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)

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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]
  - प्राचीनभारतीयसंस्कृतेः, दर्शनं भाषातत्त्वज्ञानं च (1) [SBS SKT 0209 AECC 4004]
  - तहंदी भाषा: रचना एवं व्यिहार [SBS HIN 0208 AECC 4004]

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
(CHOICE BASED CREDIT SYSTEM)

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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

Note:

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    - प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1) [SBS SKT 0209 AECC 4004]
    - तहंदी भाषा: रचना एवं व्यिहार [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:
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SEC-02

1. Computational Physics Skills [SBS PHY 03 401 SE 0042]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 3104	3	1	0	4
2	Solid State Physics	SBS PHY 03 502 CC 3104	3	1	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

Note: 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 3104	3	1	0	4
2	Statistical Mechanics-I	SBS PHY 03 602 CC 3104	3	1	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

Note: 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]
3. Computational Methods in Physics: Theory [SBS PHY 03 603 DS 4004] + Laboratory [SBS PHY 03 604 DS 0042]

DSE-04

1. Astronomy and Astrophysics [SBS PHY 03 605 DS 5106]
2. Embedded systems- Introduction to Microcontroller [SBS PHY 03 606 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]

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
(CHOICE BASED CREDIT SYSTEM)

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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 3104	3	1	0	4
2	Advanced Mathematical Physics	SBS PHY 03 702 CC 3104	3	1	0	4
3	Advanced Quantum Mechanics	SBS PHY 03 703 CC 3104	3	1	0	4
4	Physics Laboratory-VII	SBS PHY 03 704 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-05)		3	1	0	4
6	Generic Elective Course (GE-05)		3	1	0	4

Note: 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 3104]
2. Introduction to Hydrogen Energy Systems [SBS PHY 03 702 DS 3104]
3. Astrophysics of Stars [SBS PHY 03 703 DS 3104]

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
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Semester VIII

Total credits: 26

S. No.	Course Title	Course Code	L	T	P	Credits
1	Classical Electrodynamics	SBS PHY 03 801 CC 3104	3	1	0	4
2	Atomic and Molecular Physics	SBS PHY 03 802 CC 3104	3	1	0	4
3	Nuclear Physics	SBS PHY 03 803 CC 3104	3	1	0	4
4	Physics Laboratory-VIII	SBS PHY 03 804 CC 00126	0	0	12	6
5	Discipline Specific Elective Course (DSE-06)		3	1	0	4
6	Discipline Specific Elective Course (DSE-07)		3	1	0	4

Note: 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 3104]
2. Solar Energy and Physics of Photovoltaic [SBS PHY 03 802 DS 3104]

DSE-07

1. General Theory of Relativity [SBS PHY 03 803 DS 3104]
2. Accelerator Physics [SBS PHY 03 804 DS 3104]
3. Characterization Techniques for Materials [SBS PHY 03 805 DS 3104]

Scheme and Syllabus of Integrated B.Sc. M.Sc. (Physics)
(CHOICE BASED CREDIT SYSTEM)

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Semester IX

Total credits: 28

S. No.	Course Title	Course Code	L	T	P	Credits
1	Condensed Matter Physics	SBS PHY 03 901 CC 3104	3	1	0	4
2	Particle Physics	SBS PHY 03 902 CC 3104	3	1	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)		3	1	0	4
6	Discipline Specific Elective Course (DSE-09)		3	1	0	4

Note: 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 3104]
2. Plasma Physics [SBS PHY 03 902 DS 3104]

DSE-9

1. Experimental Techniques in Nuclear and Particle Physics [SBS PHY 03 903 DS 3104]
2. Reactor Physics [SBS PHY 03 904 DS 3104]
3. Advanced Carbon Materials [SBS PHY 03 905 DS 3104]

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:

- Student may opt for full semester long dissertation work on the campus or outside the campus in some Laboratories/Institutes/Universities of National Importance.
- For carrying out the dissertation work outside the campus, student will have to produce an invitation/acceptance letter from external supervisor by the end of Semester III.
- Student may complete the dissertation project under the guidance of a supervisor on CUH campus.
- Student who will pursue the project outside CUH will have one internal supervisor and one external supervisor.
- Internal supervisor will continuously monitor the progress of research work of student in consultation with external supervisor. He/She will be responsible for internal assessment of the candidate from time to time.
- Student will be allowed to work with external supervisor at other outside institutions only after completing all the documentation process at CUH. Students have to follow the timeline strictly issued by Department from time to time.
- Department will have no financial obligation if student carries out the dissertation work outside CUH.

Course Contents

(for Semester I to VI)

1. Core courses
2. Discipline Specific Elective courses
3. Skill Enhancement Elective courses
4. Generic Elective Courses

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 I** 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.	15
2	**Calculus II** Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. 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	17
3	**Integration** 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).	14
4	**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **Introduction to probability:** Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples	14

	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">COURSE SYLLABUS</td></tr>
</table>

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 force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram.	14

	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 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="5">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="5"><table>
<tr><th>Topics</th><th>Description with Applications</th></tr>
<tr><td>Introduction and Overview</td><td>Computer architecture and organization, memory and Input/output devices</td></tr>
<tr><td>Basics of scientific computing</td><td>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</td></tr>
<tr><td>Errors and error Analysis</td><td>Truncation and round off errors, Absolute and relative errors, Floating point computations.</td></tr>
<tr><td>Review of C & C++ Programming fundamentals</td><td>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</td></tr>
<tr><td>Programs:</td><td>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</td></tr>
<tr><td>Random number generation</td><td>Area of circle, area of square, volume of sphere, value of pi (π)</td></tr>
</table></td><td>30</td></tr>
</table>

<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 of 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 $0 \le t \le 15$
The differential equation describing the motion of a pendulum is $\frac{d^2\vartheta}{dt^2} = -sin(\vartheta)$. The pendulum is released from rest at an angular displacement α, i.e. $\vartheta(0) = \alpha$ and $\vartheta'(0) = 0$. Solve the equation for α= 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small $\vartheta(sin(\vartheta)) = \vartheta$</td></tr>
</table>
</td>
<td>30</td>
</tr>
<tr>
<td colspan="3">
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.

</td>
</tr>
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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 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">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: magnetic field due to current-carrying straight wire, circular loop (at a point on its axis),	15

	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 Wave**s** **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 Publication**s.**
- 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 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="5">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="5">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 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">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.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating</td><td>60</td></tr>
</table>

	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>Scheme Version:

2021-26</td><td>Name of the subject:

Mathematical Physics–II</td><td>L

4</td><td>T

0</td><td>P

0</td><td>C

4</td><td colspan="2">Semester: III</td><td>Contact Hours per Week: 4

Total Hours: 60</td></tr>
<tr><td>Subject Code:
SBS PHY 03 301 CC 4004</td><td>Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td>Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="4">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td></td><td></td><td></td><td>TEE</td><td>70 Marks</td><td colspan="4">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="8">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="8">● 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="8">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="9">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.	16
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 withexamples, 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	16
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 Most Probable Speeds. Degrees of Freedom. Law of Equipartition of	14

	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.	14

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. Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation	15

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:

2021-26</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: 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 03 304 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">● 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.</td><td>60</td></tr>
</table>

	● 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>
<tr><th>#</th><th colspan="5">List of Experiments</th><th>Hours</th></tr>
<tr><td>1</td><td colspan="5">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>
</table>

2	**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. ● 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	20
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. ● 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

Scheme Version: 2021-26	**Name of the subject:** Mathematical Physics-III	**L**	**T**	**P**	**C**	**Semester: IV**	**Contact Hours per Week:** 4
		4	0	0	4		**Total Hours: 60**
Subject Code: SBS PHY 03 401 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:** Mathematical Physics-I and Mathematical Physics-II		
Course Description	This course aims at providing knowledge of Complex Analysis, Integrals Transforms, Fourier Transforms, Laplace Transform and also their applications in various branches of Physics.						
Course Objectives	● 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.						
Course Outcomes	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.						

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Complex Analysis-I:** Brief Revision of Complex Numbers and their GraphicalRepresentation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and	12

	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">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="3">Subject Code:
SBS PHY 03 402 CC 4004</td><td rowspan="3">Applicable to Program:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="3">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></td><td></td><td></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, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.</td></tr>
</table>

	• 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. **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.	14

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:

2021-26</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

Scheme Version: 2021-26	**Name of the subject:** Physics Laboratory-IV	**L**	**T**	**P**	**C**	**Semester: IV**	**Contact Hours per Week:** 12
		0	0	12	6		**Total Hours:** 180
Subject Code: SBS PHY 03 404 CC 00126	**Applicable to Program: Integrated B.Sc. M.Sc. (Physics)**	**Evaluation (Total Marks: 150)**	**CIE**	45 Marks	**Examination Duration:** 3 hours (Practical)		
			TEE	105 Marks	**Prerequisite of Course:** None		

#	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. 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	60

	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: 3 + 1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 501 3104</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
Mathematical Physics</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.
● Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.</td></tr>
</table>

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, stationarystates and energy eigenvalues; expansion of an arbitrary wavefunction asa 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.	15
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.	15
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 excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.	15

	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.	15

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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 502 CC 3104</td><td rowspan="2">Applicable to Program: Integrated BSc-MSc 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, X-ray diffraction, lattice dynamics, various crystal bonding, electric polarization, ferroelectric domains, 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 and bonding in solids, 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.
● Understand the theories and phenomena of lattice dynamics, and various bonding in solids
● Explain the dielectric phenomenon in crystals with their exciting properties and learn the basics of ferroelectric crystals.
● Illustrate some exciting phenomena such as Meissner effect, Isotope effect, London’s equations, and BCS theory of superconductors.
● Understand the basics of high temperature superconductors and commercial applications of superconductors</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">Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice</td><td>15</td></tr>
</table>

	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.	
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. T^3 law. **Bonding in Solids:** Interatomic forces and types of bonding (basic idea). Binding energy in ionic crystals, evaluation of Madelung constant. Binding energy of crystal of Inert gases.	15
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.	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. High Temperature Superconductors (basic idea), Applications of Superconductors.	15

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** **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 t	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>Scheme Version:

2021-26</td><td>Name of the subject:
Electromagnetic Theory</td><td>L
3</td><td>T
1</td><td>P
0</td><td>C
4</td><td>Semester: VI</td><td>Contact Hours per Week:
3 + 1
Total Hours: 60=45+15</td></tr>
<tr><td>Subject Code:
SBS PHY 03 601 CC 3104</td><td>Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td>Evaluation (Total Marks: 100)</td><td>CIE
TEE</td><td>30 Marks
70 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)
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.	15
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 dielectricmedia- Laws of Reflection & Refraction. Fresnel's Formulae forperpendicular & 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.	15
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. **Rotatory Polarization:** Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of	15

	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	15

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>Scheme Version:

2021-26</td><td>Name of the subject:
Statistical Mechanics</td><td>L
3</td><td>T
1</td><td>P
0</td><td>C
4</td><td>Semester: VI</td><td>Contact Hours per Week:
3 + 1
Total Hours: 60=45+15</td></tr>
<tr><td>Subject Code:
SBS PHY 03 602 CC 3104</td><td>Applicable to Program: Integrated B.Sc. M.Sc. (Physics)</td><td>Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td></td><td></td><td></td><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="5">Content of Each Unit</td><td colspan="2">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.	15
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.	15
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.	15
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.	15

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: VI</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="6">List of Experiments</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">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.
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>90</td></tr>
</table>

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:

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: 5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60 + 15</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 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: 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.	**19**
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.	**19**

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.	**19**
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).	**18**

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:

2021-26</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:
5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60 + 15</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.	19
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	19
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.	19

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:

2021-26</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:
5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60 + 15</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	19
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.	19

	(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.	19

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:

2021-26</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=60+15</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 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</td></tr>
</table>

	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, angular momentum, parity, magnetic moments, electric moments, **Nuclear Models**: Liquid drop model approach, semi empirical mass formula and significance of its various terms, 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 nuclear force.	19
2	**Radioactivity decay**: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, (a) α-decay spectroscopy, (b) energy kinematics for beta-decay, positron 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).	19
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 interaction with 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	19

	tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	
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	18

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: 5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</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	19
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	19

	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.	18
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.	19

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: 5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</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)	19
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	19
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. **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	19

	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: 5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</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	19
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.	19
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:
Medical Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester: VI</td><td>Contact Hours per Week:
5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</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.	19
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 **Detectors**: ionization (Thimble chamber, condenser chamber), chamber.	19

	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. **Medical Instrumentation:** Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.	15

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.

Computational Methods in Physics

Scheme Version: 2021-26	**Name of the subject:** Computational Methods in Physics	**L**	**T**	**P**	**C**	**Semester: VI**	**Contact Hours per Week:** 3+1
		3	1	0	4		**Total Hours: 60=45+15**
Subject Code: SBS PHY 03 603 DS 3104	**Applicable to Program: Integrated BSc-MSc Physics**	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours (Theory)		
			TEE	70 Marks	**Prerequisite of Course:** None		

#	Contents	Hours
1	**Numerical Computing:** Numerical data, Numeric and Digital computing, process and characteristics of numerical computing, Evolution of numerical computing and computers, Problem-solving and algorithms, Flowcharts, Structuring the logic. **Approximations and Errors in Computing:** Significant digits, Inherent errors, Numerical errors, Modelling errors, Blunders, Absolute and Relative errors, Error propagation, Conditioning and Stability, Convergence of Iterative processes, Error Estimation, Minimizing the total error.	15
2	**Roots of Non-linear and linear equations:** Non-linaer equations: Iterative methods, Bisection method, False position method, Newton-Raphson method, Secant method, Fixed-point method; Linear equations: Gauss's elimination method, Gauss-Jordan method, triangular factorization method, matrix inversion method, Jacobi Iteraction method, Gauss-Seidel method. **Numerical Solution of Ordinary Differential Equations (First and Second Order):** Taylor series method, Taylor series method for simultaneous first/second order differential equations, Picard's method of successive approximations, Euler's method, Modified Euler's method. Runge-Kutta methods: Second, third and fourth order Runge-Kutta Methods, Runge-Kutta methods for simultaneous first order differential equations, Runge-Kutta methods for second order differential equations.	15
3	**Interpolation:** Introduction to Finite differences: Newton's forward and backward difference interpolation formula, Central difference	15

	interpolation formulae: Gauss's formula, Stirling's formula. Interpolation with unevenly spaced points: Lagrange's formula, Cubic Spline Interpolation. **Numerical Differentiation and Integration:** Numerical differentiation using Newton's forward and backward difference formula, Newton-Cotes quadrature formula of Numerical Integration, Trapezoidal rule, Simpson's one-third rule, Simpson's three-eight rule, Higher order rules.	
4	**Eigenvectors and eigenvalues:** homogeneous equations, characteristic equation. Method and secant method. Order of convergence in different Power method, Jacobi, Given's and Householder's methods **Random Number generators:** True random numbers and pseudo-random numbers, mid-square method, multiplicative congruential generator, tests for randomness; Applications: nuclear radioactivity, brownian motion.	15

TEXT BOOKS

- Introduction to Numerical Analysis, S.S. Sastry, Ed. V., 2012, PHI Learning
- 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, Ed. III, 2007, Wiley India Edition.
- Numerical methods, E. Balagurusamy, 2016, Tata McGraw Hill.
- Object Oriented programming with C++, E. Balagurusamy, 2016, Tata McGraw Hill.

Computational Methods in Physics (Laboratory)

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</td><td rowspan="2">Name of the subject:

Computational Methods in Physics (Laboratory)</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>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 03 604 DS 0042</td><td rowspan="2">Applicable to Program: Integrated BSc-MSc 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)</td></tr>
<tr><td>TEE</td><td>35 Marks</td><td colspan="3">Prerequisite of Course:
None</td></tr>
<tr><td>#</td><td colspan="5">Contents</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="5">Programming exercises (and corresponding physics applications) using different methods:
1. To find roots of linear and non-linear equations
2. To find numerical solutions of ordinary differential equations (First and Second Order)
3. For Interpolation</td><td>30</td></tr>
<tr><td>2</td><td colspan="5">Programming exercises (and corresponding physics applications) using different methods:
1. For numerical integration and differentiation
2. To find eigenvalues and eigenvectors
3. To generate pseudo-random numbers</td><td>30</td></tr>
<tr><td colspan="7">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)</td></tr>
</table>

- 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.
- Numerical methods, E. Balagurusamy, 2016, Tata McGraw Hill.
- Object Oriented programming with C++, E. Balagurusamy, 2016, Tata McGraw Hill.

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:
5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 605 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.	19
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).	19

	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.	18
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).	19

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: 5 + 1</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 75=60+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 606 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.	19
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.	19
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	18

	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	19

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

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</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 03 302 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 transmission characteristics of several interference filters. Computer simulation can also be done.	15

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

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>
<tr><td>#</td><td colspan="6">Contents</td><td>Hours</td></tr>
<tr><td>1</td><td colspan="6">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.</td><td>20</td></tr>
</table>

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), LoopingStatements (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.

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).

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: V</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)

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 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:

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:
30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 601 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 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 equivalentdose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gasdetectors (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),	8

	Archaeology, Art, Crime detection, Mining and oil. Industrial 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]

Offered by Department of Physics and Astrophysics to students of other departments

1. Mechanics [GE] (Theory + Laboratory)
2. Electricity and Magnetism [GE] (Theory + Laboratory)
3. Waves and Optics [GE] (Theory + Laboratory)
4. Modern Physics [GE] (Theory + Laboratory)

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 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">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.
6. To determine the Elastic Constants of a Wire by Searle’s method.</td><td>60</td></tr>
</table>

	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 3104</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). **Electrostatics I:** 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.	15
2	**Electrostatics II:** 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 electricfield 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.	15
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 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		

#	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]

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</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:

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 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><th>#</th><th colspan="5">List of Experiments</th><th>Hours</th></tr>
<tr><td>1</td><td colspan="5">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, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.</td></tr>
</table>

	• 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: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.	15

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]

Scheme Version: 2021-26	**Name of the subject:** Modern Physics Laboratory [GE]	**L**	**T**	**P**	**C**	**Semester: IV**	**Contact Hours per Week:** 4
		0	0	4	2		**Total Hours:** 60
Subject Code: SBS PHY 03 402 GE 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		

#	List of Experiments	Hours
1	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.	60

	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:

2021-26</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>
<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: 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>18</td></tr>
<tr><td>2</td><td colspan="6">Speaking Skills:
Monologue
Dialogue
Group Discussion
Effective Communication/ Mis- Communication
Interview
Public Speech</td><td>14</td></tr>
<tr><td>3</td><td colspan="6">Reading and Understanding
Close Reading
Comprehension
Summary Paraphrasing
Analysis and Interpretation
Translation(from Indian language to English and vice-versa)
Literary/Knowledge Texts</td><td>14</td></tr>
</table>

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

Scheme Version: 2021-26	Name of the subject: Environmental Sciences	L	T	P	C	Semester: I/II	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS EVS 0107 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 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

प्राचीनभारतीयसंस्कृ तिः , दर्नं भाषातिज्ञानं च (1)
Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)

माध्यमिः – संस्कृ त/तिन्दी/आंग्लभाषा
Medium – Sanskrit/Hindi/English

Scheme Version: 2021-26	Name of the subject: प्राचीनभारतीयसंस्कृ तिः , दर्नं भाषातिज्ञानं च (1) Prācīnabhāratīyasaṁskṛtiḥ, Darśanaṁ Bhāṣāvijñānaṁ Ca (1)	L	T	P	C	Semester: I/II	Contact Hours per Week: 4
		4	0	0	4		Total Hours: 60
Subject Code: SBS SKT 0209 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 Obejctive	1. संस्कृ तेतर-तिषयाणामध्येतृभ्यिः संस्कृ ताध्ययनाय सौकयोत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां िेदातद-र्ास्त्राणामुपतनषदां च रुतचरुत्पादनम्; 3. संस्कृ तेनोपतनबद्धानां नीततिाक्यानां गीतायां ितणतस्य कमयोगस्य च तत्त्व-संधारणाय यत्नः ; 4. सामान्य-भाषातिज्ञानस्य पररचयिः ।						
Course Outcomes	• अध्येतारिः िेदातद-र्ास्त्राणामुपतनषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नर्ीलाः भिेयु । • व्याहाररकदृष्ट्या संस्कृ तज्ञानेन अन्यतिषयाणामध्येतारिः तत्तद् स्वतिषयानुगुणं संस्कृ तभाषायामुप-लभ्यमानानां ग्रन्थानां प्रतत यत्नर्ीलाः स्यु । • िेदोपतनषत्–गीता–नीततर्ास्त्र–भाषार्ास्त्रादीनां तिषयाणां सम्यगध्ययनेनास्माकं पूिजानां िैदुष्येण पररचयिः संजायेत। • भारतीय-तचन्तनपरम्परायाि समृद्धं ज्ञातुमयं पाठ्यक्रमिः प्रकृ ष्टमाध्यमिः संजायेत।						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	मन्त्राणां सन्दभानां श्लोकानां च व्याख्या सारसंक्षेपश्च – (क) यजुिेद (34. 1-6)-तरिसंकल्पमन्त्राः ; (ख) तैत्तरीयोपतनषद् - तर्क्षाल्ली (अनुर्ासनोपतनषद्)	15
2	मन्त्राणां सन्दभानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भतहरिः - नीततर्तकम् : 1-50 श्लोकाि:	15
3	मन्त्राणां सन्दभानां श्लोकानां च व्याख्या सारसंक्षेपश्च – भगिद्गीता – तृतीयाध्याय (कमयोग)	15

4	मन्त्राणां सन्दर्भाणां श्लोकानां च व्याख्या सारसंक्षेपश्च –	15

	सामान्यभाषातिज्ञानम्- (क) विणमाला, विणानाम् उच्चारणस्थानातन प्रयत्नाश्च; (ख) भाषातिज्ञानस्य सामान्य पररचयिः, भाषापररितनस्य कारणातन, अर्थपररितनस्य कारणातन च	

TEXT BOOKS

/अनुशंसतग्रन्थाि:

1. उिव्ट-महीधर, रुक्लयजुिेदभाष्य, मोतीलाल बनारसीदास, तदल्ली, 2007
2. स्वामी दयानन्द सरस्वती, यजुिेदभाष्य, सम्पा० ब्रह्मदत्त तजज्ञासु, रामलाल कपूर टस्ट, सोनीपत (हररयाणा)
3. तैतत्तरीयोपतनषद् , तहन्दी व्याख्याकार - स्वामी प्रखर प्रज्ञानन्द सरस्वती, कार्ी, 2013
4. भतहरर, नीततरतक, सम्पादक एिं तहन्दी व्याख्याकार - जनादन र्ास्त्री पाण्डे य, मोतीलाल बनारसीदास, तदल्ली, 2014
5. नीततरतकम्, 'नीततपर्' तहन्दी व्याख्याकार - राजेश्वर रास्त्री मुसलगािकर, चौखम्भा, िाराणसी
6. श्रीमद्भगिद्गीता (तहन्दी अनुिाद सतहत), गीता प्रैस, गोरखपुर, 2015
7. श्रीकृष्ण तिपाठी, श्रीमद्भगिद्गीता (तितीय, तृतीय एिं चतुर्ि अध्याय), 2005
8. देिीदत्त र्मा, भातषकी और संस्कृत भाषा, हररयाणा सातहत्य अकादमी, चण्डीगढ़, 1990
9. कतपलदेि तिेदी, भाषा-तिज्ञान एिं भाषा-र्ास्त्र, तिश्वतिद्यालय प्रकार्न, चौक, िाराणसी, 2012
10. कणतसंह, भाषातिज्ञान, सातहत्य 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

तिंदी भाषा: रचना एि व्यि◌ि◌ार

Scheme Version: 2021-26	Name of the subject: तहंदी भाषा: रचना एि व्यिहार	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	भाष◌ा, व्य◌ाकरण एि◌ं सातहत्य के◌े साम◌ान्य स्वरूप क◌ा तहदतर◌् ।						
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:

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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 701 CC 3104</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 Hamilton's Principles:** Mechanics of one and many particle systems, Virtual work, Constraints of motion, generalized coordinates, D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, dissipation function, simple applications of Lagrangian formulation. Calculus of Variations, Hamilton's Principle, Derivation of Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, Symmetry Properties of space and time, Conservation theorems	15
2	**Hamilton's Equations of Motion and Small Oscillations:** 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. Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator.	15
3	**Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation, Angular momentum, Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation for Principal and characteristic function, Harmonic Oscillator Problem, Action angle variable: adiabatic invariance of action variable.	15
4	**Two-body Central Force problem and Rigid Body Motion:** Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent 1D problem, classification of orbits, Differential equation for the orbit, Kepler's problem, Scattering cross section, Rutherford's Formula. Orthogonal transformation, Euler equations, Eulerian angles ad Euler's Theorem, Infinitesimal rotation, Rate of change of a vector, Coriolis force, Angular Momentum and Kinetic energy of a rigid body, moment of Inertia, Eigenvalues of the inertia tensor.	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.
- 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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 702 CC 3104</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.	15
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	15
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.	15

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.	15

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 Quantum 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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 703 CC 3104</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 a
● 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
● 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</td></tr>
</table>

	● 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.	15
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 integration method: Probability amplitude as path integral, action, free particle and harmonic oscillator motion, Wick's Theorem. Scattering matrix.	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.
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 03 704 CC 00126</td><td rowspan="2">Applicable to Programs:
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</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">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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 801 CC 3104</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="3">Subject Code:
SBS PHY 03 802 CC 3104</td><td rowspan="3">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="3">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:
3 hours (Theory)</td></tr>
<tr><td rowspan="2">TEE</td><td rowspan="2">70 Marks</td><td colspan="3" rowspan="2">Prerequisite of Course:
Modern Physics</td></tr>
<tr></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>
</table>

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

<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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 803 CC 3104</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 theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">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</td><td>15</td></tr>
</table>

	theory.	
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, rotational model.	15
4	**Nuclear Reactions:** Reaction mechanism, compound nuclei and direct reactions, heavy ion reactions, fusion-fission dynamics, Quantum mechanical fragmentation theory, Radioactive ion beams, cross-section, Nuclear Dynamics at Intermediate and high energies, Isospin dependent and independent models, Multifragmentation, Directed flow, elliptical flow, nuclear stopping, Experimental Scenario.	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:

VIII</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 03 804 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>45 Marks</td><td colspan="3">Examination Duration:

3 hours</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">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: 3 +1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 901 CC 3104</td><td rowspan="2">Applicable to Program: Integrated BSc-MSc 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</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to convey the advance understanding about energy bands, magnetic and optical properties in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">● To understand the energy band phenomenon in solids
● To make acquainted with magnetic and optical properties of solids
● To develop the scientific and positive attitudes in students related to the condensed matter physics
● To able the students for solve the problems related to condensed matter physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
● Learn various exciting phenomena such as electron behaviour in periodic potential, effective mass and tight-binding approximation.
● Understand the theories and phenomena of diamagnetism, paramagnetism, and ferromagnetism.
● Explain the origin of domains in magnetic materials.
● Illustrate some exciting phenomena such as optical refractive index, relative dielectric constant and luminescence in solids.</td></tr>
<tr><td colspan="8">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>1</td><td colspan="5">Energy Bands in Solids: Electron in Periodic Potential, Bloch Function, Kroning-Penney Model of Behaviour of an Electron in a Periodic Potential. Velocity and Effective Mass of an Electron. E-K Relationships in Various representations: Reduced, Periodic and Extended Zone Schemes. Energy Band Calculations: Origin of the Energy Gap, Nearly Free Energy and Tight-Binding Approximations. Construction of Fermi Surfaces in Brillouin zones for Two – Dimensional Lattices</td><td colspan="2">15</td></tr>
<tr><td>2</td><td colspan="5">Diamagnetism and Paramagnetism: Langevin’s Theory of Diamagnetism, Quantum Theory of Diamagnetism: Mononuclear</td><td colspan="2">15</td></tr>
</table>

	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.	
3	**Magnetic Ordering:** 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
4	**Optical Properties of Solids:** Classical Model (Drude-Model), Ionic Conduction, Optical Refractive Index and Relative Dielectric Constant, Optical Absorption in Metals, Insulators, and Semiconductors, Luminescence of Solids, Types of Luminescence Systems, The Excitons: Weakly Bound Excitons and Tight Bound Excitons. Color Centers.	15

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
- B. D. Culity and C. D. Grahim, Introduction to Magnetic Materials, Wiley, USA, 2nd Edition, 2008.
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03
902 CC 3104</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>45 Marks</td><td colspan="3">Examination Duration:

3 hours</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">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	90
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.	90

	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:
3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 03 701 DS 3104</td><td rowspan="2">Applicable to Programs:
Integrated B.Sc. M.Sc. (Physics)</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CI E</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TE E</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
● Compare microstates, macrostates, and statistical ensembles</td></tr>
</table>

	● 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 Heat; Grand partition function For Ideal Bose Gas; Black-Body Radiation; Bose-Einstein Condensation, Fermions:	15

	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:

2021-26</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03
702 DS 3104</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 inindustry, 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 byautomotive 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>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
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:** 3+1
		3	1	0	4		**Total Hours: 60=45+15**
Subject Code: SBS PHY 03 703 DS 3104	**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	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:

2021-26</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 801 DS 3104</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>
<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">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.</td><td>15</td></tr>
</table>

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:

2021-26</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:
3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 03
802 DS 3104</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 ofwater, 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:

2021-26</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 803 DS 3104</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="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="5">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 colspan="2">15</td></tr>
<tr><td>2</td><td colspan="5">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 colspan="2">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:

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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 804 DS 3104</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 805 DS 3104</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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 901 DS 3104</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- Walker metric - Observable quantities – luminosity and angular diameter</td><td>15</td></tr>
</table>

	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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 902 DS 3104</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

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</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:

IX</td><td>Contact Hours per Week: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 03 903 DS 3104</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:
Basics of Nuclear Physics 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:
● 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.</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	**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: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 904 DS 3104</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="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="5">Nuclear Reactions: Characteristics of atomic nucleus, Binding energy, Nuclear fission, Cross section, Interaction of neutrons with nuclei.</td><td colspan="2">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:
3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 905 DS 3104</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>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="5">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 one allotropic form into another, phase diagram of carbon, new carbon structures: discovery of C_{60}, Graphene and Nanotubes</td><td colspan="2">15</td></tr>
</table>

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.

GE courses

(for Semester VII onwards)

Indian Knowledge System*

Scheme Version: 2021-26	**Name of the subject:** Indian Knowledge System	**L**	**T**	**P**	**C**	**Semester:** VII/VIII	**Contact Hours per Week:** 3+1
		3	1	0	4		**Total Hours: 60=45+15**
Subject Code: SBS 03 07 GE 3104	**Applicable to Programs:** Integrated B.Sc. M.Sc.	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		

** The course will be taught by the faculty members of School of Basic Sciences.*

Course Objective	• This course will provide an opportunity to the learners to know the contribution of the great Indian Scientists to Science.
Course Outcomes	After completing this course, Students are expected to be familiar with great Indian scientists and their contributions in the development of scientific knowledge and nation building.

COURSE SYLLABUS

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Physics**: Bibliography of Scientists in the field of Physics, basics of Raman Spectroscopy and Raman Effect, Bhabha Scattering, Indian rocket technology, Wireless transmission of electromagnetic waves, Strong-weak coupling duality, Indian Satellite Technology, Indian Missile Man, Bose-Einstein Condensation, fabrication of ultralight aircraft and sailboats. Chandersekhar limit, Thermal ionization of elements, Saha equation, Pokhran atomic bomb, Quantum black holes, ISRO satellite, fabric and composition of Universe	15
2	**Chemical Sciences:**Bibliography of Scientists in the field of Chemical Sciences. Contribution made by the Chemists of Ancient India like Nagarjuna and Kanada.Solid-state and structural chemistry, multiferroic oxides and perovskites, Introduction of vinca alkaloids	15

	and their applications, Shanti Swaroop Bhatnagar - "Father of Research Laboratories" in India, contribution in industrial research and role in establishments of CSIR, Founder of theIndia's first pharmaceutical company, research on pharmace uticals including nitrites, investigation of radio and microwave optics,controlled synthesis of proteins, total synthesis of a functional gene outside a living organism, Debashis Mukherjee and Theoretical spectroscopy, many-body methods for electronic structures, Crystal Engineering, weak Hydrogen bonds and co-crystals, Determination of the atomic structure of 30S ribosomal subunit, modern Indian Coordination Chemistry, structures and reactivity of transition-element compounds	
3	**Mathematics:**Bibliography and contribution of Indian Mathematicians: Aryabhatta, Brahmagupta, Bhaskara I, Bhaskara II, Srinivasa Ramanujan, Shakuntala Devi, Manjul Bhargava, Akshay Venkatesh. **Statistics:**Bibliography and contribution of Indian Statisticians:C. R. Rao, Prasanta Chandra Mahalanobis, Debabrata Basu, K. C. Sreedharan Pillai, Pranab K. Sen, Raj Chandra Bose.	15
4	**Geography:**Contribution of Varahamihira, Brahmagupta, Bhaskaracharya, Aryabhata and Ancient Indian Literature to the development of scientific knowledge in the field of geography. **Computer Science:** Knowledge discovery and knowledge management in ancient India, protection of traditional knowledge, need and significance for protecting traditional knowledge, Systems of traditional knowledge protection, Traditional knowledge, and intellectual property, patents and traditional knowledge, strategies to increase protection of traditional knowledge.	15

TEXT BOOKS

1. Science India, ScientificMagazines by Vijnana Bharati. For details visit: https://scienceindiamag.in.
2. Everyman's Science by ISCA. For details visit: http://www.sciencecongress.nic.in.
3. Evolution of Geographical Thought, Husain, M., 2012, Rawat Publications.
4. Knowledge Traditions and Practices of India (a text book) 2012, Kapil Kapoor, MichelDanino.
5. E-resources: https://www.youtube.com/watch?v=LZP1StpYEPM, http://nptel.ac.in/courses/121106003.
6. Probability and Statistical Inference, Mukhopadhyay, N., 2000. Marcel Dekker, Inc. New York.

Numerical Methods and Programming

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</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:

VII/VIII</td><td>Contact Hours per Week: 2+1+2</td></tr>
<tr><td>2</td><td>1</td><td>2</td><td>4</td><td>Total Hours: 30+15+30</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 702 GE 2124</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. 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 :
• to write a computer program in C.
• the solutions of linear and non-linear equations along with solutions of simultaneous linear equations.
• Numerical differentiation and integration.
• Monte Carlo methods and its application to problems of physical world.</td></tr>
<tr><td colspan="8">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>1</td><td colspan="5">C/C++:
Flow charts, Algorithms, Input and output statements, Control statements, Arrays, Repetitive and logical structures, Subroutines and functions.</td><td colspan="2">18</td></tr>
<tr><td>2</td><td colspan="5">Numerical Methods of Analysis:
Roots of a function, Solution of simulteneous linear</td><td colspan="2">19</td></tr>
</table>

	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.	19
4	Simulations II : Inhomogeneous distribution and Importance of datasampling, Metropolis algorithm, Brownian motion as random walk problem and its Monte-Carlo simulation.	19

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, NewDelhi, 4th Edition, 2015.
6. V. Rajaraman, Computer Programming in FORTRAN 90/95, Prentice Hall of India, New Delhi, 1st Edition, 2015.

Physics of Digital Photography

<table>
<tr><td rowspan="2">Scheme Version:

2021-26</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:

VII/VIII</td><td>Contact Hours per Week: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 703 GE 3104</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. 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 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>
</table>

Course Outcomes	On completion of the course, student would be able: • To understand the photographic optics & methods • To understand the basic principle of photography • To understand the theory of exposure • To understand about the image quality

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, Tonecurves, 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 toPhotographic Lighting by Understanding Color in Photography by Bryan Peterson.
6. **Andy Rowland**, Physics of Digital Photography by (IOP Publishing).

Modern Optics

<table>
<tr><td rowspan="2">Scheme Version :

2021-26</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:

VII/VIII</td><td>Contact Hours per Week: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 801 GEC 3104</td><td rowspan="2">Applicable to Programs: Integrated B.Sc. 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 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">1. To understand the fundamentals of optics.
2. To impart knowledge about different physical phenomena.
3. 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:
Understand the various physical phenomena & their real life applications.
Learn about the wave optics and holography.
Get knowledge about the basics of Lasers.
Learn about the fiber optics & LED.</td></tr>
<tr><td colspan="8">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	**An overview of Geometrical and Wave Optics:** Laws of Reflection, Refraction, Total Internal Reflection; Ideas ofInterference, 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 Gainand 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, 2nd Edition, 1989.
3. **J. T. Verdeyen,** Laser Electronics, Prentice-Hall, India,New Delhi, 3rd Edition, 1995.
4. **E. Hecht,** Optics, Addison Wesley, USA, 4th Edition, 2001.
5. **Pedrotti,**Introduction to Optics, Pearson UK, 3rd Edition, 2006.
6. **B. E. A. Saleh and M. C. Teich,** Fundamentals of Photonics, Wiley,United States, 2nd Edition, 2012.
7. **A. Ghatak,** Optics, Tata McGraw-Hill, New Delhi, 6th Edition, 2017.

60=

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:

VII/VIII</td><td>Contact Hours per Week: 3+1</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60=45+15</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 03 802 GE 3104</td><td rowspan="2">Applicable toPrograms: Integrated B.Sc. 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: 10+2with 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:
• To understand the concepts like energy transformations and various forms of energy, climate change and its effect on living beings
• To understand the concepts like thermodynamics and its applications to various energy transformation processes.
• To develop an awareness of climate change and its effects
• To develop an awareness of different fossil fuels and their alternatives</td></tr>
<tr><td colspan="8">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	**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. TheCarnot 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, UnitedStates, 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, NewDelhi, 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

9. University Press, 4th Edition, 2005.
10. **P. Hughes**, **N. J. Mason**, Introduction to Environmental Physics: Planet Earth, Life and Climate,Taylor & Francis, France, 1st Edition, 2005.
11. **J. Monteith** and **M. Unsworth**, Principles of Environmental Physics: Plants, Animals and theAtmosphere, Elsevier, 4th Edition, Europe, 2013.

K.L. Kumar, Engineering Fluid Mechanics, S. Chand, New Delhi, 4th Edition, 2016

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