CENTRAL UNIVERSITY OF HARYANA

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

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi

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

(Batch 2021-2026)

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
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Table of Contents

Sr. No.	Contents	Page No.
	Vision and Mission	**03**
1	**Background** **i) Preamble** **ii) Introduction** **iii) Learning Outcomes Based Approach to Curriculum Planning** **iv) Nature and Extent of Integrated B.Sc.-M.Sc. (Mathematics) Programme**	**04** **05** **06** **06**
2	**Aims of Integrated B.Sc.-M.Sc. (Mathematics) Programme**	**07**
3	**Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)**	**08**
4	**Integrated B.Sc.-M.Sc. Attributes**	**10**
5	**Qualification Descriptors for Integrated B.Sc.-M.Sc. (Mathematics)(Possible Career Pathways):**	**11**
6	**Structure of Integrated B.Sc.-M.Sc. (Mathematics) Programme**	**12**
7	**Course Types**	**13**
8	**Semester wise Details of Integrated B.Sc.-M.Sc. (Mathematics) Course & Credit Scheme**	**17**
9	**Generic Elective Courses (for other departments only)**	**100**
10	**Teaching-Learning Process**	**123**
11	**Implementation of Blended Learning**	**123**
12	**Assessment and Evaluation**	**124**
13	**Keywords**	**125**
14	**References**	**125**
15	**Appendix: (i) List of Courses in Integrated BSc-MSc, and MSc Mathematics programs** **(ii) Structure of Question Papers and Marks Distribution**	**126**

VISION AND MISSION

Vision and Mission of the University

Vision

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

Mission

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

Vision and Mission of the Department

Vision

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

Mission

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

1. Background

i) Preamble

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

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms. At the outset, it may well be stated that NEP 2020 document owes it origin to meet the fundamental challenges of ever changing academics scales at Global level. Thus, a high priority task in the context of future education development agenda in India is fostering quality higher education. The idea is to involve young minds in knowledge production and of greater participation of knowledge itself. Participation in knowledge, by young minds, is an important departure from the existing structure at undergraduate level. Implementation of new structure is based on guiding principles of Learning Outcome based Curriculum Framework (LoCF). The fundamental premise underlying the learning outcome based approach to curriculum planning and development is that higher education qualifications such as Bachelor-Master integrated degree programme are awarded on the basis of demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of Graduate-Master of a programme of study. The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the Bachelor-Master integrated

with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen student's experiences as they engage themselves in the programme of their choice. The Graduate-Master programme will prepare the students for academia and also prepare them to use this knowledge for employment. The given programme elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programme also state the attributes that it offers to inculcate at the graduation level. The Bachelor-Master integrated attributes encompass values related to wellbeing, emotional stability, critical thinking, and also skills for employability. The programme prepares students for sustainability and lifelong learning. This also tries to change the perception towards studying mathematics. This course is designed to break the stereotypes of mathematics learning and create interest amongst students to do Mathematics. This programme is organized to provide the greatest flexibility to its students. There are Core Disciplinary papers that provide the fundamental knowledge in the discipline of mathematics. The programme is otherwise envisaged to provide a large amount of choice so that students can adapt their education on the basis of their interests. These provide not just mathematical knowledge and skills but also a vital skill in other disciplines as well.

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

ii) Introduction:

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

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

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

iii) Learning Outcomes Based Approach to Curriculum Planning:

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

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

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

Mathematics is usually described as the abstract science of number, quantity and space along with their operations. The scope of Mathematics is very broad and it has a wide

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

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

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

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

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

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

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

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

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

Program Outcomes:

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

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

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

Programme Specific Outcomes (PSOs):

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

i. Demonstrate fundamental/systematic and coherent knowledge of the academic field of mathematics and its applications and links to engineering, science, technology, economics and finance; demonstrate procedural knowledge that create different professionals like teachers and researchers in mathematics, quantitative analysts, actuaries, risk managers, professionals in industry and public services.

ii. Demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.

iii. Demonstrate comprehensive knowledge about materials, including scholarly, and/or professional literature, relating to essential learning areas pertaining to the field of mathematics, and techniques and skills required for identifying mathematical problems.

iv. Apply the acquired knowledge in mathematics and transferable skills to new/unfamiliar contexts and real-life problems.

v. Demonstrate mathematics-related and transferable skills that are relevant to some of the job trades in education sector, entrepreneurship and employment opportunities.

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

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

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

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

7. Course Type

Core Courses (CC)

Generic Elective Courses (GEC)

Discipline Specific Elective Courses (DSEC)

Skill Enhancement Courses (SEC)

Ability Enhancement Compulsory Courses (AECC)

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

CORE COURSES (CC)

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

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

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

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

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)*:

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

SKILL ENHANCEMENT ELECTIVE COURSES (SEC)*:

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

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

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

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

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

8. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

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

(CHOICE BASED CREDIT SYSTEM)

Semester I

Total credits: 22

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

Semester II

Total credits: 22

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

Semester III

Total credits: 28

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

Semester IV

Total credits: 28

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

Semester V

Total credits: 24

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

Semester VI

Total credits: 24

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

COURSE-LEVEL LEARNING OUTCOMES

Course Structure

SEMESTER – I

<table>
<tr><td>Course No: 1</td><td colspan="3">Course Name: Calculus (P)</td><td colspan="3">Course Code: SBSMAT 03 01 01 C 4046</td></tr>
<tr><td rowspan="2">Batch:

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

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

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td>Total Hours: 120</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, compactness, differentiability, and integrability, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical skill.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
• Understand the method of successive differentiation and Taylor series expansions.
• Be familiar with concepts of asymptotes, curvature and singular points.
• Apply the concepts of calculus for tracing and rectification of the curves in Cartesian, parametric and polar coordinates.
• Understand reduction formulae and be familiar with the method of finding</td></tr>
</table>

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

Books Recommended:

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

List of Practical (using any software)

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

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

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

(iii) Obtaining surface of revolution of curves.

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

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

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

Course No: 2	**Course Name:** Algebra			Course Code: SBSMAT 03 01 02 C 5106			
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** I	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours					
		Pre-requisite of course: N.A.					

Course Objective	The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.
Course Outcomes:	After going through this course the students will be able to • Work with the trigonometric form of complex numbers including De-Moivre's formula. • Be familiar with the Euler form $re^{i\theta}$ of complex numbers • Apply the elementary operations on the matrices. Compute the eigenvalues, eigen function, characteristic equation and minimal polynomial of a given matrix. • Obtain the solution of the systems of linear equations using the concept of rank of matrices

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Equivalence relations, Functions, Composition of functions,	23

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

Books Recommended:

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

Course No: 03	**Course Name:** Environmental Sciences				Course Code: SBSMAT 03 01 01 AECC 3104		
Batch:	**Programme:**	**Semester :**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2026	**Integrated B.Sc.-M.Sc. (Mathematics)**	**I**	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					

Course Objective	To aware the students the need for sustainable development, problems of pollution, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, the depletion of ozone layer, loss of biodiversity and need of worldwide efforts in its conservation.	
	After going through this course the students will be able to • Get the knowledge about trends of biological diversity and conservation strategies and thereafter be able to create awareness for its conservation and development. • Understanding of issues concerning different natural resources will be helpful to find scientific solution based on participatory approach. • Know about the local environmental issues, movements and an important role to minimize the impact of these aspects. • Knowledge about the types of pollution and pollution control	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	Definition, scope and importance of the environmental science, Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.	15
II	Introduction, kinds of ecosystem, structure and functions, abiotic and biotic component, Ecological energetics, Energy flow models, Food chain and Food web, Ecological Pyramids-types, Ecological succession, Introduction, types, structure and function of the following ecosystem :- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic	15

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

Books Recommended:

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

Course No: 04	**Course Name:** प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)				**Course Code:** SBSMAT 03 01 02 AECC 3104		
Batch:	**Programme:**	**Semester :**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2026	**Integrated B.Sc.-M.Sc. (Mathematics)**	**I**	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					
Course Objective /उद्देश्यः	1. संस्कृतेतर-विषयाणामध्येतृभ्यः संस्कृताध्ययनाय सौकर्योत्पादनम्; 2. भारतीयज्ञानसंपदाधारभूतानां वेदादि-शास्त्राणामुपनिषदां च रुचिरुत्पादनम्; 3. संस्कृतेनोपनिबद्धानां नीतिवाक्यानां गीतायां वर्णितस्य कर्मयोगस्य च तत्त्व-संधारणाय यत्नः; 4. सामान्य-भाषाविज्ञानस्य परिचयः।						
	पाठ्यक्रमाध्ययनस्य फलम् / Course Level Learning Outcome: ●अध्येतारः वेदादि-शास्त्राणामुपनिषदां च तत्त्वान् ज्ञात्वा स्वाध्याय प्रयत्नशीलाः भवेयुः। ●व्यावहारिकदृष्ट्या संस्कृतज्ञानेन अन्यविषयाणामध्येतारः तत्तद् स्वविषयानुगुणं संस्कृतभाषायामुप- लभ्यमानानां ग्रन्थानां प्रति यत्नशीलाः स्युः। ●वेदोपनिषत्–गीता–नीतिशास्त्र–भाषाशास्त्रादीनां विषयाणां सम्यगध्ययनेनास्माकं पूर्वजानां वैदुष्येण परिचयः संजायेत। ●भारतीय-चिन्तनपरम्परायाः समृद्धिं ज्ञातुमयं पाठ्यक्रमः प्रकृष्टमाध्यमः संजायेत।						
Unit No.	**Content of Each Unit**						**Hours of Each Unit**
I	**घटकम्-1:** (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)						15
II	**घटकम्-2:** भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः						15

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

अनुशंसितग्रन्थाः -

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

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

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

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

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

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

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

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

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

10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ

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

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

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

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

SEMESTER – II

Course No: 05	**Course Name:** Real Analysis				**Course Code:** SBSMAT 03 02 01 C 5106		
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** II	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					

Course Objective	This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighborhood of a point, countable sets , sequence and series, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing
Course Outcomes:	After going through this course the students will be able to • Identify the properties of the number system and Describe various analytical properties of the real number system. • Explain the concept of sequences and their types and Identify the convergence of sequences and series of positive terms. • Apply various important convergence tests to the given series. • Understand the difference between conditional and absolute convergence of alternating series.

Unit No.	**Content of Each Unit**	**Hours of**

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

Books Recommended:

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

<table>
<tr><td>Course No: 06</td><td colspan="3">Course Name: Differential Equations (P)</td><td colspan="4">Course Code: SBSMAT 03 02 02 C 4046</td></tr>
<tr><td rowspan="2">Batch:

2021-2026</td><td rowspan="2">Programme: Integrated B.Sc.-M.Sc. (Mathematics)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td>Total Hours: 120</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE:

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

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

List of Practical (using any software)

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

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

Books Recommended:

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

Course No: 07	**Course Name: हिंदी भाषा : रचना एवं व्यवहार .**				**Course Code:** SBSMAT 03 02 01 AECC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 04**
2021-2026	**Integrated B.Sc.-M.Sc. (Mathematics)**	**II**	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					
Course Objective	• भाषा, व्याकरण एवं साहित्य के सामान्य स्वरूप का निदर्शन।						
Course Outcomes:	• भाषा, बोली और व्याकरण के विविध घटकों का परिचय। • संचार माध्यमों के स्वरूप और भाषा का ज्ञान। • रचना पाठ से साहित्य बोध।						

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	भाषा की परिभाषा एवं विशेषताएं भाषा और व्याकरण हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)	15
II	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

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

अनुशंसित पुस्तकें :

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

Course No: 08	**Course Name:** English				**Course Code:** SBSMAT 03 02 02 AECC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 04**
2021-2026	**Integrated B.Sc.-M.Sc. (Mathematics)**	**II**	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					

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

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

Books Recommended :

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

SEMESTER – III

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

Course No: 09	**Course Name:** Multivariable Calculus				**Course Code:** SBSMAT 03 03 01 C 5106		
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** III	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.						
Course Outcomes:	After going through this course the students will be able to • Learn conceptual variations while advancing from one variable to several variables in calculus. • Apply multivariable calculus in optimization problems. • Inter-relationship amongst the line integral, double and triple integral formulations. • Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc. • Realize importance of Green, Gauss and Stokes' theorems in other branches of mathematics.						

Content of Each Unit	**Hours of Each Unit**
Unit-I: Partial Differentiation Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.	18
Unit-II: Differentiation	18

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

References:

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

Course No: 10	Course Name: Group Theory		Course Code: SBSMAT 03 03 02 C 5106				
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** III	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	To introduce basic structures of algebra like group, dihedral groups, permutation group, Abelian group, non-Abelian group and cyclic group which are the main pillars of modern group theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.						
Course Outcomes	After going through this course the students will be able to • Recognize the mathematical objects called groups. • Link the fundamental concepts of groups and symmetries of geometrical objects. • Explain the significance of the notions of cosets, normal subgroups, and factor groups. • Analyze consequences of Lagrange's theorem. • Learn about structure preserving maps between groups and their consequences.						

Content of Each Unit	Hours
Unit-I: Groups and its Elementary Properties Symmetries of a square, Definition and examples of groups including dihedral, permutation and quaternion groups, Elementary properties of groups.	18
Unit-II: Subgroups and Cyclic Groups Subgroups and examples of subgroups, Cyclic groups, Properties of cyclic groups, Lagrange's theorem, Euler phi function, Euler's theorem, Fermat's little theorem.	18
Unit-III: Normal Subgroups Properties of cosets, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Classification of subgroups of cyclic groups.	18

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

References:

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

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

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

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

References:

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

<table>
<tr><td>Course No: 12</td><td colspan="3">Course Name:
Logic, Sets and Graph Theory</td><td colspan="4">Course Code: SBSMAT 03 03 01 SEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 04</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce students with the fundamental concepts in set, logic and graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Analyze the truth and falsity of a logical statement and differentiate between a logical statement and an ordinary statement.
• Define and describe various properties of sets.
• Describe the fundamental properties of Graph Theory.
• Identify different representations of a Graph for practical applications.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Logic
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.</td><td>12</td></tr>
<tr><td colspan="7">Unit-II: Set Theory
Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.</td><td>12</td></tr>
</table>

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

References:

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

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

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

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

References:

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

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

SEMESTER – IV

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

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

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

References:

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

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

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

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

References:

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

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

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

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

References:

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

<table>
<tr><td>Course No: 18</td><td colspan="3">Course Name: Object Oriented Programming in C++</td><td colspan="4">Course Code: SBSMAT 03 04 01 SEC 3024</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 75</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Write C++-Programs to solve Mathematical problems.
• Design algorithms to solve problems.
• Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism.
• Emphasize on the importance of use of Friend Functions for efficient C++ programming.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I Characteristics of Object-Oriented Programming Languages
OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.</td><td>15</td></tr>
<tr><td colspan="7">Unit-II Implementing OOPS Concepts in C++
Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables withFunctions.</td><td>15</td></tr>
<tr><td colspan="7">Unit-III Abstract Data Types
Abstract data types, Class Component, Object & Class, Constructors Default and Copy</td><td>15</td></tr>
</table>

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

References:

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

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

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

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

References:

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

Course No: 20	**Course Name: ********** GE4		**Course Code: ********* GE 5106				
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: IV**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – V

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

Course No: 21	Course Name: Set Theory and Metric Spaces						Course Code: SBSMAT 03 05 01 C 5106
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: V**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	To providing the basic knowledge pertaining to metric spaces such as open and closed balls, neighborhood, interior, closure, subspace, continuity, compactness, connectedness etc.						
Course Outcomes	After going through this course the students will be able to • Learn basic facts about the cardinality of a set. • Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano-Weierstrass property, compactness, and connectedness. • Identify the continuity of a function defined on metric spaces and homeomorphisms						

Content of Each Unit	**Hours**
Unit-I: Theory of Sets Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder-Bernstein theorem, Cantor's theorem, Order relation in cardinal numbers, Arithmetic of cardinal numbers, Partially ordered set, Zorn's lemma and Axiom of choice, Various set theoretic paradoxes.	18
Unit-II: Concepts in Metric Spaces Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.	18

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

References:

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

Course No: 22	**Course Name:** Advanced Algebra			**Course Code:** SBSMAT 03 05 02 C 5106			
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The objective of the course is to introduce modern structures of algebra like group actions, orbits and stabilizers, rings and fields, field extensions and finite fields which are the main pillars of modern algebra. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.						
Course Outcomes	After going through this course the students will be able to • Understand the basic concepts of group actions and their applications. • Recognize and use the Sylow theorems to characterize certain finite groups. • Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields. • Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.						

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

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

References:

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

Course No: 23	Course Name: Tensors and Differential Geometry					Course Code: SBSMAT 03 05 01 DSE 5106	
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.						
Course Outcomes	After going through this course the students will be able to • Explain the basic concepts of tensors. • Understand role of tensors in differential geometry. • Learn various properties of curves including Frenet-Serret formulae and their applications. • Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae. • Understand the role of Gauss's Theorem a Egregium and its consequences.						

Content of Each Unit	Hours
Unit-I: Tensors Contravariant and covariant vectors, Transformation formulae, Tensor product of two vector spaces, Tensor of type (*r*, *s*), Symmetric and skew-symmetric properties, Contraction of tensors, Quotient law, Inner product of vectors.	18
Unit-II: Further Properties of Tensors Fundamental tensors, Associated covariant and contravariant vectors, Inclination of two vectors and orthogonal vectors, Christoffel symbols, Law of transformation of Christoffel symbols, Covariant derivatives of covariant and contravariant vectors, Covariant differentiation of tensors, Curvature tensor, Ricci tensor, Curvature tensor identities.	18

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

References:

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

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

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

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

References:

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

<table>
<tr><td>Course No: 25</td><td colspan="3">Course Name: Integral Transforms and Fourier Analysis</td><td colspan="4">Course Code: SBSMAT 03 05 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course is aimed at exposing the students to learn the Laplace transforms and Fourier transforms. To equip with the methods of finding Laplace transform and Fourier Transforms of different functions. To make them familiar with the methods of solving differential equations, partial differential equations, IVP and BVP using Laplace transforms and Fourier transforms.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Know about piecewise continuous functions, Dirac delta function, Laplace transforms and its properties.
Solve ordinary differential equations using Laplace transforms.
Familiarise with Fourier transforms of functions belonging to $L^1(\mathbb{R})$ class, relation between Laplace and Fourier transforms.
Explain Parseval’s identity, Plancherel’s theorem and applications of Fourier transforms to boundary value problems.
Learn Fourier series, Bessel’s inequality, term by term differentiation and integration of Fourier series.
Apply the concepts of the course in real life problems.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Laplace Transforms
Laplace transform, Linearity, Existence theorem, Laplace transforms of derivatives and integrals, Shifting theorems, Change of scale property, Laplace transforms of periodic functions, Dirac’s delta function.</td><td>18</td></tr>
</table>

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

References:

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

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

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

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

References:

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

<table>
<tr><td>Course No: 27</td><td colspan="3">Course Name:
Information and Coding Theory</td><td colspan="4">Course Code: SBSMAT 03 05 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The Mathematics program promotes mathematical skills and knowledge for their intrinsic beauty, effectiveness in developing proficiency in analytical reasoning, and utility in modeling and solving real world problems. Students who have learned to logically question assertions, recognize patterns, and distinguish the essential and irrelevant aspects of problems can think deeply and precisely, nurture the products of their imagination to fruition in reality, and share their ideas and insights while seeking and benefiting from the knowledge and insights of others.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Study simple ideal statistical communication models.
• Understand the development of codes for transmission and detection of information.
• Learn about the input and output of a signal via transmission channel.
• Study detection and correction of errors during transmission.
• Represent a linear code by matrices - encoding and decoding.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Concepts of Information Theory
Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Entropy Function
A sketch of communication network, Entropy, Basic relationship among different entropies, A measure of mutual information, Interpretation of Shannon’s fundamental</td><td>18</td></tr>
</table>

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

References:

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

Course No: 28	**Course Name:** Graph Theory					**Course Code:** SBSMAT 03 05 06 DSE 5106	
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The objective of the course is to introduce students with the fundamental concepts of graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.						
Course Outcomes	After going through this course the students will be able to • Appreciate the definition and basics of graphs along with types and their examples. • Understand the definition of a tree and learn its applications to fundamental circuits. • Know the applications of graph theory to network flows. • Understand the notion of planarity and coloring of a graph. • Relate the graph theory to the real-world problems.						

Content of Each Unit	**Hours**
Unit-I: Paths, Circuits and Graph Isomorphisms Definition and examples of a graph, Subgraph, Walks, Paths and circuits; Connected graphs, disconnected graphs and components of a graph; Euler and Hamiltonian graphs, Graph isomorphisms, Adjacency matrix and incidence matrix of a graph, Directed graphs and their elementary properties.	18
Unit-II: Trees and Fundamental Circuits Definition and properties of trees, Rooted and binary trees, Cayley's theorem on a counting tree, Spanning tree, Fundamental circuits, Minimal spanning trees in a connected graph.	18
Unit-III: Cut-Sets and Cut-Vertices Cut-set of a graph and its properties, Fundamental circuits and cut-sets, Cut-vertices, Connectivity and separability, Network flows, 1- isomorphism and 2- isomorphism.	18

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

References:

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

Course No: 29	Course Name: Special Theory of Relativity						Course Code: SBSMAT 03 05 07 DSE 5106
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** V	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The course provides a comprehensive introduction to the general theory of relativity where all forms of gravity can be described as a purely geometric effect where the curvature of space and time follows the distribution of energy and the amount momentum the matter has. An overview is given of the classical tests of theory, and how the theory is used to describe black holes, gravitational waves, and the cosmological evolution of the universe. The course also provides an introduction to differential geometry, which is necessary to be able to both formulate and apply the theory.						
Course Outcomes	After going through this course the students will be able to • Understand the basic elements of Newtonian mechanics including Michelson-Morley experiment and geometrical interpretations of Lorentz transformation equations. • Learn about length contraction, time dilation and Lorentz contraction factor. • Study 4-dimensional Minkowskian space-time and its consequences. • Understand equations of motion as a part of relativistic mechanics. • Imbibe connections between relativistic mechanics and electromagnetism.						

Content of Each Unit	**Hours**
Unit-I: Newtonian Mechanics Inertial frames, Speed of light and Gallilean relativity, Michelson-Morley experiment, Lorentz-Fitzgerold contraction hypothesis, Relative character of space and time, Postulates of special theory of relativity, Lorentz transformation equations and its geometrical interpretation, Group properties of Lorentz transformations.	18
Unit-II: Relativistic Kinematics	18

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

References:

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

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

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

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

References:

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

SEMESTER – VI

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

<table>
<tr><td>Course No: 31</td><td colspan="3">Course Name: Complex Analysis</td><td colspan="4">Course Code: SBSMAT 03 06 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To providing the basic knowledge and to finds basic ideas of analysis for complex functions in complex variables with visualization through relevant practical’s. Particular emphasis has been laid on Cauchy’s theorems and series expansions.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere.
• Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.
• Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
• Apply Liouville’s theorem in fundamental theorem of algebra.
• Understand the convergence, term by term integration and differentiation of a power series.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Complex Plane and functions.
Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Analytic Functions and Cauchy-Riemann Equations
Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 32</td><td colspan="3">Course Name: Numerical Analysis</td><td colspan="4">Course Code: SBSMAT 03 06 02 C 4046</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem:VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>4</td><td>0</td><td>4</td><td>6</td><td>Total Hours: 120</td></tr>
<tr><td>Course Objective</td><td colspan="7">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Obtain numerical solutions of algebraic and transcendental equations.
Find numerical solutions of system of linear equations and check the accuracy of the solutions.
Learn about various interpolating and extrapolating methods.
Solve initial and boundary value problems in differential equations using numerical methods.
Apply various numerical methods in real life problems.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Numerical Methods for Solving Algebraic and Transcendental Equations
Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.</td><td>24</td></tr>
<tr><td colspan="7">Unit-II: Numerical Methods for Solving Linear Systems
Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a</td><td>24</td></tr>
</table>

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

References:

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

Course No: 33	Course Name: Discrete Mathematics					Course Code: SBSMAT 03 06 01 DSE 5106	
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** VI	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations, trees and graphs.						
Course Outcomes	After going through this course the students will be able to • Learn about partially ordered sets, lattices and their types. • Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications. • Solve real-life problems using finite-state and Turing machines. • Assimilate various graph theoretic concepts and familiarize with their applications.						

Content of Each Unit	**Hours**
Unit-I: Partially Ordered Sets Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.	18
Unit-II: Lattices Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.	18

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

References:

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

<table>
<tr><td>Course No: 34</td><td colspan="3">Course Name: Wavelets and Applications</td><td colspan="4">Course Code: SBSMAT 03 06 02 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">Most students today have had experience downloading compressed image or sound files from the web, or using software such as Adobe Photoshop to enhance a photo they have taken, or watching a crime solving drama where the fingerprints of a perpetrator are compared against those stored in AFIS. This course uses mathematical theory, recently developed applications, and computation to introduce students to the basics of the enhancement and compression of digital image and sound files. Students from mathematics, physics, and computer science might benefit from such a course.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Know basic concepts of signals and systems.
Understand the concept of Haar spaces.
Learn Fourier transform and wavelet transform of digital signals.
Learn applications of wavelets to the real-world problems.
Apply wavelets in signal processing and image processing.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Signals and Systems
Basic concepts of signals and systems, Frequency spectrum of signals; Classification of signals: Discrete time signals and continuous time signals, periodic and non-periodic signals; Classification of systems: Linear, nonlinear, time-variant, time-invariant, stable and unstable systems.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Haar Scaling Function and Wavelet, Time-Frequency Analysis
Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions,</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 35</td><td colspan="3">Course Name: Number Theory</td><td colspan="4">Course Code: SBSMAT 03 06 03 DSE 5106</td></tr>
<tr><td rowspan="2">Batch:
2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course is aimed at undergraduate mathematics majors. It is a first course in number theory, and is intended to introduce students to number theoretic problems and to different areas of number theory. Number theory has a very long history compared to some other areas of mathematics, and has many applications, especially to coding theory and cryptography.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Wilson's theorem and their consequences.
• Learn about number theoretic functions, modular arithmetic and their applications.
• Familiarize with modular arithmetic and find primitive roots of prime and composite numbers.
• Know about open problems in number theory, namely, the Goldbach conjecture and twin-prime conjecture.
• Apply public crypto systems, in particular, RSA.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Distribution of Primes and Theory of Congruencies
Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Twin-prime conjecture, Odd perfect numbers conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 36</td><td colspan="3">Course Name: Mathematical Finance</td><td colspan="4">Course Code: SBSMAT 03 06 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course provides an introduction to the basic mathematical concepts and techniques used in finance and business, highlighting the inter-relationships of the mathematics and developing problem solving skills with a particular emphasis on financial and business applications..</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand financial markets and derivatives including options and futures.
• Appreciate pricing and hedging of options, interest rate swaps and no-arbitrage pricing concepts.
• Learn stochastic analysis, Ito’s formula, Ito integral and the Black−Scholes model.
• Study and use Hedging parameters, trading strategies and currency swaps.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Basic Theory of Interest and Fixed-Income Securities
Principal and interest: simple, compound and continuous; Present and future value of cash flow streams; Net present value, Internal rates of return and their comparison; Inflation, Annuities; Bonds, Bond prices and yields, Macaulay duration and modified duration.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Term Structure of Interest Rates, Bonds and Derivatives
Spot rates, forward rates and explanations of term structure; Running present value, Floating- rate bonds, Immunization, Convexity; Putable and callable bonds; Exchange-traded markets and over-the-counter markets; Derivatives: Forward contracts, Future contracts, Options, Types of traders, Hedging, Speculation, Arbitrage.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 37</td><td colspan="3">Course Name: Cryptography</td><td colspan="4">Course Code: SBSMAT 03 06 05 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">Cryptography is the practice and study of techniques for securing communications in the presence of third parties. This course aims to impart knowledge and protect information in order to ensure its integrity, confidentiality, authenticity, and non-repudiation. This course gives with a basic understanding of cryptographic concepts and how to apply them, implement secure protocols, key management concepts, key administration and validation, and Public Key Infrastructure.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the difference between classical and modern cryptography.
Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards (DES & AES) and RSA.
Encrypt and decrypt messages using block ciphers, sign and verify messages using well-known signature generation and verification algorithms.
Know about the aspects of number theory which are relevant to cryptography.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit I: Introduction to Cryptography and Classical Cryptography
Cryptosystems and basic cryptographic tools: Secret-key cryptosystems, Public-key cryptosystems, Block and stream ciphers, Hybrid cryptography, Message integrity: Message authentication codes, Signature schemes, Nonrepudiation, Certificates, Hash functions, Cryptographic protocols, Security; Hybrid cryptography: Message integrity, Cryptographic protocols, Security, Some simple cryptosystems, Shift cipher, Substitution cipher, Affine cipher, Vigenère cipher, Hill cipher, Permutation cipher, Stream ciphers, Cryptanalysis of affine, substitution, Vigenère, Hill and LFSR stream ciphers.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 38</td><td colspan="3">Course Name: Advanced Mechanics</td><td colspan="4">Course Code: SBSMAT 03 06 06 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2021-26</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">In this course, students will be imparted knowledge to enable them to understand several concepts of Advanced Mechanics such as Central axis, Wrench, Impulsive motion, Streamlines, pathlines, Moments and products of inertia.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand the reduction of force system in three dimensions to a resultant force acting at a base point and a resultant couple, which is independent of the choice of base of reduction.
• Learn about a null point, a null line, and a null plane with respect to a system of forces acting on a rigid body together with the idea of central axis.
• Know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia and to derive Euler’s equations of motion of a rigid body, moving about a point which is kept fixed.
• Study the kinematics and kinetics of fluid motions to understand the equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates which are used to derive Euler’s equations and Bernoulli’s equation.
• Deal with two-dimensional fluid motion using the complex potential and also to understand the concepts of sources, sinks, doublets and the image systems of these with regard to a line and a circle.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Statics in Space
Forces in three dimensions, Reduction to a force and a couple, Equilibrium of a system of particles, Central axis and Wrench, Equation of the central axis, Resultant wrench of two wrenches; Null points, lines and planes with respect to a system of forces, Conjugate forces and conjugate lines.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Motion of a Rigid Body</td><td>18</td></tr>
</table>

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

References:

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

Course No: 39	**Course Name:** Dissertation on Any Topic of Mathematics				**Course Code:** SBSMAT 03 06 07 DSE 5106		
Batch: 2021-26	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:VI**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**

9. GENERIC ELECTIVE COURSES (GEC)

(Only for Other Departments)

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

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

Course No: 01	**Course Name:** Object Oriented Programming in C++				**Course Code:** SBSMAT 03 01 01 GE 4046		
Batch:	**Programme: UG**	**Semester: I**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 08**
	Integrated B.Sc.-M.Sc. (Mathematics)		4	0	4	6	**Total Hours: 120**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours **Pre-requisite of course:**					
Course Objective	The main objective of this course is to define and highlight the importance of object oriented programming. The students will see how to use concepts of object oriented programming in real-life using C++ programming language. The students will learn potential C++ features like overloading, type conversions, inheritance.						
	After going through this course the students will be able to • Write C-programmes to solve Mathematical problems. • Design algorithms to solve problems. • Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism. • Emphasize on the importance of use of Friend Functions for efficient C++ programming.						
Unit No.	**Content of Each Unit**						**Hours of Each Unit**
I	OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-						30

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

Books Recommended:

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

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

2021-2026</td><td>Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td>Semester:

II</td><td>L

5</td><td>T

1</td><td>P

0</td><td>Credits

6</td><td>Contact Hrs per Week: 06

Total Hours: 90</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE:
TEE:</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course includes an introduction about different finite element methods in one- two and three-dimensions. The course focuses on analyzing variety of finite elements as per the requirements of solutions of differential equations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After going through this course the students will be able to
Describe finite element methods
Differential equations using finite element methods
Emphasize on the importance of use of Simplex elements in two and three dimensions.
Understand the Interpolation functions, numerical integration and modeling considerations.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin’s method. Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.</td><td colspan="2">23</td></tr>
</table>

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

Books Recommended:

1. J.N. Reddy, Introduction to the Finite Element Methods, Tata McGraw-Hill, 2003, **(Textbook).**
2. K.J. Bathe, Finite Element Procedures, Prentice-Hall, 2001**.**
3. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, John Wiley and Sons, 2002.
4. T. J.R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publication, 2000**.**
5. G. R. Buchanan, Finite Element Analysis, McGraw Hill, 1994.

Course No: 3	**Course Name:** Algebra			**Course Code:** SBSMAT 03 01 03 GE 5106			
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** I	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours					
		Pre-requisite of course: N.A.					
Course Objective	The objective of the course is to introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.						
Course Outcomes:	After going through this course the students will be able to • Work with the trigonometric form of complex numbers including De-Moivre's formula. • Be familiar with the Euler form $re^{i\Theta}$ of complex numbers • Apply the elementary operations on the matrices. Compute the eigen values, eigen function, characteristic equation and minimal polynomial of a given matrix. • Obtain the solution of the systems of linear equations using the concept of rank of matrices						
Unit No.	**Content of Each Unit**						**Hours of Each Unit**

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

Books Recommended:

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

<table>
<tr><td>Course No: 4</td><td colspan="3">Course Name: Econometrics</td><td colspan="4">Course Code: SBSMAT 03 02 01 GE 5106</td></tr>
<tr><td>Batch:

2021-2026</td><td>Programme:

Integrated B.Sc.-M.Sc. (Mathematics)</td><td>Semester:

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

CIE:

TEE:</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course:</td></tr>
<tr><td>Course Objective</td><td colspan="7">Econometrics is a set of research tools used to estimate and test economic relationships. The methods taught in this introductory course can also be employed in the business disciplines of accounting, finance, marketing and management and in many social science disciplines. The aim of this course is to provide you with the skills helpful in filling the gap between being “a student of economics” and being “a practicing economist.”</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students should be able to
• Design models and solve problems related to Economic issues.
• Describe the Statistical Concepts
• Understand the Detection, Remedies and Multicollinearity.
• Be familiars with the Type I and Type II errors.</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>I</td><td colspan="5">Statistical Concepts Normal distribution; chi-square, t and F-</td><td colspan="2">22</td></tr>
</table>

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

Books Recommended:

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

Course No: 5	**Course Name:** Mathematical Finance				**Course Code:** SBSMAT 03 02 02 GE 5106		
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** II	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours					

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

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

Books Recommended:

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

Course No: 06	**Course Name:** Real Analysis				**Course Code:** SBSMAT 03 02 03 GE 5106		
Batch: 2021-2026	**Programme: Integrated B.Sc.-M.Sc. (Mathematics)**	**Semester:** II	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Total Evaluation Marks: 100 **CIE:** **TEE:**		**Examination Duration:** 3 hours					
		Pre-requisite of course:					

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

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

Books Recommended:

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

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

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

References:

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

<table>
<tr><td>Course No: 08</td><td colspan="3">Course Name: Basic Mathematics for Social Sciences</td><td colspan="4">Course Code: SBSMAT 03 03 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of this course is to encourage students to develop a working knowledge of the basic Mathematics for social science and will present some of the ideas that form the foundation of quantitative work in the social sciences. In particular, topics from logarithm, set theory, matrix theory and calculus will be discussed with emphasis on the understanding ofconcepts and the development of intuition.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Explain the fundamental concepts of indices, logarithm and antilogarithm and their role in basic Mathematics for social science.
• Demonstrate accurate and efficient use of set theory and Venn diagram.
• Understand and use the terms: function, relation, series arithmetic, geometric progression, Permutations and Combinations.
• Understand the concepts and properties of limits, continuity and differentiation of a function, logical reasoning, probability and descriptive statistics</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I
Binary numbers, indices, logarithm and antilogarithm, laws and properties of logarithms, simple applications of logarithm and antilogarithm, numerical problems on averages, calendar, clock, time, work and distance, mensuration, seating arrangement, sets, types of sets, Venn diagram, De Morgan's laws, problem solving using Venn diagram, relations and types of relations.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II
Introduction of sequences, series arithmetic and geometric progression, relationship between AM and GM. Basic concepts of permutations and combinations, permutations, combinations with standard results. Introducing functions, domain and range of a function, types of functions (Polynomial function; Rational function; Logarithm function, Exponential function; Modulus function; Greatest Integer function, Signum function), Graphical representation of functions.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 09</td><td colspan="3">Course Name: Probability and Statistics</td><td colspan="4">Course Code: SBSMAT 03 03 03 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses. After taking this course, students will be able to use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB, to perform simple and sophisticated analyses for large samples.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand distributions in the study of the joint behaviour of two random variables.
Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Probability Functions and Moment Generating Function
Basic notions of probability, Conditional probability and independence, Baye’s theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Univariate Discrete and Continuous Distributions
Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.</td><td>18</td></tr>
<tr><td colspan="7">Unit-III: Bivariate Distribution
Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.</td><td>18</td></tr>
</table>

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

References:

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

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

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

References:

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

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

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

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

References:

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

<table>
<tr><td>Course No: 12</td><td colspan="3">Course Name: Numerical Methods</td><td colspan="3">Course Code: SBSMAT 03 04 03 GE 3104</td></tr>
<tr><td rowspan="2">Batch:</td><td>Program: UG</td><td>Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td></td><td></td><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems
Find the Numerical solutions of Non-linear equations
Familiarize the students with advantages and limitations of numerical techniques
Solve interpolation problems, difference equations and Eigen value problems</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit I Nature of numerical computations: errors and their propagation</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Numerical solution of systems of linear equations: Direct methods for solving linear systems, error analysis. The residual correction method. Iteration methods, Error prediction and Acceleration.</td><td>18</td></tr>
<tr><td colspan="7">Unit-III: Matrix Eigenvalue problem: Eigenvalue location, error, and stability results, Power method. Orthogonal transformations using Householder matrices. The eigenvalues of a symmetric Tridiagonal matrix. QR method. The calculation of Eigenvectors and Inverse iteration.</td><td>18</td></tr>
<tr><td colspan="7">Unit-IV: Numerical solutions of Non-linear equations: Solution of non-linear equations by iterative methods, acceleration of convergence. Newton’s methods for polynomials,</td><td>18</td></tr>
</table>

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

References:

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

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

10. Teaching-Learning Process

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

11. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face-to-face classroom methods with computer-based activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments face-to-face learning, giving ample freedom and flexibility to the students and

teachers to access and explore wide range of open-access resources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face-to-face learning. The blended learning does not undermine the role of a teacher; rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

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

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

12. Assessment and Evaluation

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

- Review of Literature
- Collaborative Assignments

13. Keywords

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

14. References

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

15. Appendix

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

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

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

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

Structure of Question Papers and Marks Distribution

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