CENTRAL UNIVERSITY OF HARYANA

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

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi

Integrated BSc-MSc (Mathematics)

(w.e.f. 2022-23)

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
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VISION AND MISSION

Vision and Mission of the University

Vision

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

Mission

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

Vision and Mission of the Department

Vision

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

Mission

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

1. Background

i) Preamble

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

1. The learning outcomes of each course/paper are designed so that these may help learners to understand the main objectives of studying the course.

2. This will enable learners to select elective courses/papers depending on the individual inclinations and contemporary requirements.

3. The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to graduate degree with honours in Mathematics or with Mathematics as a subject.

4. These syllabi in Mathematics under CBCS are recommended keeping in view applications of Mathematics in science, engineering, social science, business and a host of other areas.

5. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.

6. The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the courses/papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.

7. The outcomes of each course/paper may be modified as per the local requirements.

8. The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help learners to complete the study of concerned paper in certain periods and prepare them for examinations.

9. The papers are organized considering the credit load in a particular semester. The core courses/papers of general interest are suggested for semesters I to IV. The elective courses and advanced courses are proposed for the Integrated BSc-MSc (Mathematics) students of semesters V and VI.

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

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

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

ii) Introduction:

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

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

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

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

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

iii) Learning Outcomes Based Approach to Curriculum Planning:

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

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

The objective of LOCF (Mathematics) is to prepare the syllabi having standard level of study. It is also aimed at prescribing standard norms for teaching-learning process and examination

pattern. Hence, the Program has been chalked out in such manner that there is scope of flexibility and innovation in

i. modifications of prescribed syllabi.
ii. teaching-learning methodology.
iii. assessment technique of students and knowledge levels.
iv. learning outcomes of courses.
v. inclusion of new elective courses subject to availability of experts in colleges/institutes/universities across the country.

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

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

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

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

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

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

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

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

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

3. Key Outcomes Underpinning Curriculum Planning and Development

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

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

4. Integrated BSc-MSc Attributes

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

4.1 Disciplinary knowledge:

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

4.2 Communications skills:

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

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

4.2.3 Ability to communicate long standing unsolved problems in Mathematics.

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

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

4.3 Critical thinking and analytical reasoning:

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

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

4.4 Problem solving:

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

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

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

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

4.5 Research-related skills:

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

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

4.6 Information/digital literacy:

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

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

4.7 Self-directed learning:

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

4.8 Moral and ethical awareness/reasoning:

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

4.9 Lifelong learning:

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

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

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

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

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

i. demonstrate fundamental systematic knowledge of Mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhance the subject specific knowledge and help in creating jobs in various sectors.

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

iii. apply knowledge, understanding and skills to identify the difficult/unsolved problems in Mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.

iv. fulfill one's learning requirements in Mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences.

v. apply one's disciplinary knowledge and skills in Mathematics in newer domains and uncharted areas.

vi. identify challenging problems in Mathematics and obtain well-defined solutions.

vii. exhibit subject-specific transferable knowledge in Mathematics relevant to job trends and employment opportunities.

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

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

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

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

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

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

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

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

7.1 Course learning outcomes

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

B.Sc. (Hons) Mathematics

CORE COURSES (14)

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (Any Four)

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

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

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

8. Course Type

Core Courses (CC)

Discipline Specific Elective Courses (DSEC)

Generic Elective Courses (GEC)

Ability Enhancement Compulsory Courses (AECC)

Skill Enhancement Courses (SEC)

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

CORE COURSES (CC)

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSEC)

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

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)*:

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

SKILL ENHANCEMENT ELECTIVE COURSES (SEC)*:

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

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

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

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

9. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

Scheme and Syllabi of Integrated BSc-MSc (Mathematics)

(CHOICE BASED CREDIT SYSTEM)

Semester I

Total credits: 22

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

Semester II

Total credits: 22

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

Semester III

Total credits: 28

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

Semester IV

Total credits: 28

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

Semester V

Total credits: 24

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

Semester VI

Total credits: 24

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

8. COURSE-LEVEL LEARNING OUTCOMES

Course Structure

SEMESTER – I

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

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

<table>
<tr><td>Course No: 1</td><td colspan="3">Course Name: Calculus</td><td colspan="4">Course Code: SBSMAT 03 01 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, compactness, differentiability, and integrability, rigorously defined. Students should also have attained a basic level of competency in developing their own mathematical skills.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
Calculate the limit and examine the continuity of a function at a point.
Understand the consequences of various mean value theorems for differentiable functions.
Sketch curves in Cartesian and polar coordinate systems.
Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td colspan="7">Unit-I: Sequences and Integration
Real numbers, Sequences of real numbers, Convergence of sequences and series, Bounded and monotonic sequences; Definite integral as a limit of sum, Integration of irrational algebraic functions and transcendental functions, Reduction formulae, Definite integrals.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Limit and Continuity
ε-δ definition of limit of a real valued function, Limit at infinity and infinite limits;</td><td>18</td></tr>
</table>

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

References:

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

Course No: 2	**Course Name:** Algebra and Geometry		**Course Code:** SBSMAT 03 01 02 C 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** I	**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 matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. Students can develop geometry with a degree of confidence and will gain fluency in the basics of Euclidean geometry. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.						
Course Outcomes	After going through this course the students will be able to • Understand the importance of roots of real and complex polynomials, learn various methods of obtaining roots and Familiarize with relations, equivalence relations and partitions. • Employ De Moivre's theorem in a number of applications to solve numerical problems. • Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank. • Find eigenvalues and corresponding eigenvectors for a square matrix. • Explain the properties of three dimensional shapes.						

Content of Each Unit	**Hours**
Unit-I: Theory of Equations and Complex Numbers Elementary theorems on the roots of an equations including Cardan's method, The remainder and factor theorems, Synthetic division, Factored form of a polynomial, The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots, Integral and rational roots; Polar representation of complex numbers, The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications.	18

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

References:

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

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

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

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

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

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

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

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

Course No: 03	Course Name: Environmental Sciences					Course Code: SBSMAT 03 01 01 AECC 3104	
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: I**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 2**
			3	1	0	4	**Total Hours: 60**
Course Objective	To create awareness for sustainable development, problems of pollution, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, depletion of ozone layer, loss of biodiversity and need of worldwide efforts in its conservation.						
	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.						

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

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

References:

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

Course No: 04	**Course Name: ********** GE1		**Course Code: ********* GE 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: I**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – II

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

<table>
<tr><td>Course No: 05</td><td colspan="2">Course Name: Multivariable Calculus</td><td colspan="5">Course Code: SBSMAT 03 02 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Learn conceptual variations while advancing from one variable to several variables in calculus.
Apply multivariable calculus in optimization problems.
Inter-relationship amongst the line integral, double and triple integral formulations.
Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.
Realize importance of Green’s, Gauss’s and Stokes’ theorems in other branches of mathematics.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Partial Differentiation
Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Differentiation
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.</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 06</td><td colspan="3">Course Name:
Ordinary Differential Equations</td><td colspan="4">Course Code: SBSMAT 03 02 02 C 5106</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program:
Integrated
BSc-MSc
(Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce ordinary differential equations, general, particular, explicit, implicit and singular solutions of a differential equation. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Understand the genesis of ordinary differential equations.
• Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
• Know Picard’s method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.
• Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
• Formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: First Order Differential Equations
Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, differential Equations in which variables are separable, Homogeneous differential equations, Linear differential equations and equations reducible to linear form, Exact differential equations,</td><td>18</td></tr>
</table>

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

References:

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

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

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

Course No: 07	**Course Name:** प्राचीनभारतीयसंस्कृतिः, दर्शनं भाषाविज्ञानं च (1)					Course Code: SBSMAT 03 02 01 AECC 3104	
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: II**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
			3	1	0	4	**Total Hours: 60**
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**
I	**घटकम्-1:** (क) यजुर्वेदः (34. 1-6)-शिवसंकल्पमन्त्राः; (ख) तैत्तिरीयोपनिषद् - शिक्षावल्ली (अनुशासनोपनिषद्)						12
II	**घटकम्-2:** भर्तृहरिः- नीतिशतकम् : 1-50 श्लोकाः						12
III	**घटकम्-3:** भगवद्गीता – तृतीयाध्यायः (कर्मयोगः)						12
IV	**घटकम्-4:** सामान्यभाषाविज्ञानम्- (क) वर्णमाला, वर्णानाम् उच्चारणस्थानानि						12

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

अनुशंसितग्रन्थाः -

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

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

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

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

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

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

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

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

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

10. कर्णसिंह, भाषाविज्ञान, साहित्य भण्डार, मेरठ

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

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

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

Ltd., New Delhi-2009

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

Course No: 08	**Course Name: हिंदी भाषा : रचना एवं व्यवहार.**				**Course Code:** SBSMAT 03 02 02 AECC 3104		
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: II**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 04**
			3	1	0	4	**Total Hours: 60**
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।						

Content of Each Unit	**Hours**
Unit –I भाषा और व्याकरण भाषा की परिभाषा एवं विशेषताएं भाषा और व्याकरण हिंदी की ध्वनियों का वर्गीकरण (स्वर, व्यंजन और वर्तनी)	12
Unit –II हिंदी की संवैधानिक स्थिति हिंदी भाषा व बोलियों का संक्षिप्त परिचय हिंदी की संवैधानिक स्थिति : राजभाषा, संपर्क भाषा और राष्ट्रभाषा कार्यालयी हिंदी : पल्लवन, संक्षेपण, टिप्पण पत्र लेखन : सरकारी, अर्द्ध-सरकारी	12
Unit –III संचार माध्यमों का स्वरूप एवं भाषा संचार माध्यमों का स्वरूप एवं भाषा	12

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

अनुशंसित पुस्तकें :

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

<table>
<tr><td>Course No: 09</td><td colspan="3">Course Name: English</td><td colspan="4">Course Code: SBSMAT 03 02 03 AECC 3104</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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 to the theory, fundamentals and tools of communication and to develop in them vital communication skills integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills. Some of these are:
Language of communication, various speaking skills such as personal communication, social interactions and communication in professional situations such as interviews, group discussions and office environments, important reading skills as well as writing skills such as report writing, notetaking etc.
While, to an extent, the art of communication is natural to all living beings, in today's world of complexities, it has also acquired some elements of science. It is hoped that after studying this course, students will find a difference in their personal and professional interactions.</td></tr>
<tr><td colspan="6">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="6">Unit –I: Theory of Communication
Introduction: Theory of Communication, Types and modes of Communication. Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication</td><td>12</td></tr>
</table>

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

References:

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

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

SEMESTER – III

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

<table>
<tr><td>Course No: 11</td><td colspan="3">Course Name: Real Analysis</td><td colspan="4">Course Code: SBSMAT 03 03 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighborhood of a point, countable sets , sequence and series, rigorously defined;. Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand many properties of the real line ℝ and learn to define sequence in terms of functions from ℝ to a subset of ℝ.
Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
Learn some of the properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Real Number System
Algebraic and order properties of ℝ, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of ℝ, The completeness property of ℝ, Archimedean property, Density of rational numbers in ℝ, Definition and types of intervals, Nested intervals property; Neighborhood of a point in ℝ, Open, closed and</td><td>18</td></tr>
</table>

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

References:

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

Course No: 12	Course Name: Group Theory		Course Code: SBSMAT 03 03 02 C 5106				
Batch: 2022-27	**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**.**

<table>
<tr><td>Course No: 13</td><td colspan="3">Course Name: Probability and Statistics</td><td colspan="4">Course Code: SBSMAT 03 03 03 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">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>
</table>

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

References:

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

<table>
<tr><td>Course No: 14</td><td colspan="3">Course Name:
Logic, Sets and Graph Theory</td><td colspan="4">Course Code: SBSMAT 03 03 01 SEC 3104</td></tr>
<tr><td rowspan="2">Batch:
2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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: 15	**Course Name:** Computer Fundamentals and Programming in C			**Course Code:** SBSMAT 03 03 02 SEC 3024			
Batch: 2022-27	**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: 16	**Course Name: ********** GE3		**Course Code: ********* GE 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: III**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – IV

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

<table>
<tr><td>Course No: 17</td><td colspan="3">Course Name: Mechanics</td><td colspan="4">Course Code: SBSMAT 03 04 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 08</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Familiarize with subject matter, which has been the single centre, to which wer drawn mathematicians, physicists, astronomers, and engineers together.
Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.
Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.
Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
Learn that a particle moving under a central force describes a plane curve and know the Kepler’s laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Statics
Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.</td><td>18</td></tr>
</table>

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

References:

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

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

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

References:

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

<table>
<tr><td>Course No: 19</td><td colspan="3">Course Name: Partial Differential Equations and Calculus of Variations</td><td colspan="4">Course Code: SBSMAT 03 04 03 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">To introduce partial differential equations, general, particular, explicit, implicit and singular solutions of a partial differential equation. This course further explains the analytic techniques in computing the solutions of various partial differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Apply a range of techniques to solve first & second order partial differential equations.
• Model physical phenomena using partial differential equations such as the heat and wave equations.
• Understand problems, methods and techniques of calculus of variations.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">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.</td><td>18</td></tr>
<tr><td colspan="7">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.</td><td>18</td></tr>
<tr><td colspan="7">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.</td><td>18</td></tr>
</table>

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: 20</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: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 05</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 75</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Write C++-Programs to solve Mathematical problems.
• Design algorithms to solve problems.
• Understand the OOPS likes Encapsulation, Data Abstraction, Inheritance and Polymorphism.
• Emphasize on the importance of use of Friend Functions for efficient C++ programming.</td></tr>
<tr><td colspan="6">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="6">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="6">Unit-II Implementing OOPS Concepts in C++
Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables with Functions.</td><td>15</td></tr>
</table>

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

References:

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

Course No: 21	Course Name: Linux Operating System and Computer Graphics						Course Code: SBSMAT 03 04 02 SEC 3104
Batch: 2022-27	**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: 22	**Course Name: ********** GE4		**Course Code: ********* GE 5106				
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem: IV**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 6**
			5	1	0	6	**Total Hours: 90**

SEMESTER – V

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

Course No: 23	Course Name: Set Theory and Metric Spaces						Course Code: SBSMAT 03 05 01 C 5106
Batch: 2022-27	**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 Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces.	18
Unit-V: Connectedness Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.	18

References:

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

<table>
<tr><td>Course No: 24</td><td colspan="3">Course Name: Advanced Algebra</td><td colspan="4">Course Code: SBSMAT 03 05 02 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce modern structures of algebra like group actions, orbits and stabilizers, rings and fields, field extensions and finite fields which are the main pillars of modern algebra. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
Understand the basic concepts of group actions and their applications.
Recognize and use the Sylow theorems to characterize certain finite groups.
Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Group Actions
Group actions, Orbits and stabilizers, Conjugacy classes, Orbit-stabilizer theorem, Normalizer of an element of a group, Center of a group, Class equation of a group, Inner and outer automorphisms of a group.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Sylow Theorems
Cauchy’s theorem for finite abelian groups, Finite simple groups, Sylow theorems and applications including nonsimplicity tests.</td><td>18</td></tr>
</table>

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

References:

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

Course No: 25	**Course Name:** Tensors and Differential Geometry					**Course Code:** SBSMAT 03 05 01 DSE 5106	
Batch: 2022-27	**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: 26	Course Name: Mathematical Logic			Course Code: SBSMAT 03 05 02 DSE 5106			
Batch: 2022-27	**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: 26</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: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 06</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>6</td><td>Total Hours: 90</td></tr>
<tr><td>Course Objective</td><td colspan="7">The 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.

<table>
<tr><td>Course No: 27</td><td colspan="3">Course Name: Linear Programming</td><td colspan="4">Course Code: SBSMAT 03 05 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: V</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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 develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, Assignment and Game Problem. Such problems arise in manufacturing resource planning and financial sectors.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Analyze and solve linear programming models of real life situations.
• Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
• Understand the theory of the simplex method.
• Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.
• Learn about the applications to transportation, assignment and two-person zero-sum game problems.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Linear Programming Problem, Convexity and Basic Feasible Solutions
Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Simplex Method
Optimality criterion, Improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.</td><td>18</td></tr>
</table>

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

References:

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

Course No: 28	Course Name: Information and Coding Theory						Course Code: SBSMAT 03 05 05 DSE 5106
Batch: 2022-27	**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 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.
Course Outcomes	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.

Content of Each Unit	**Hours**
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.	18
Unit-II: Entropy Function A sketch of communication network, Entropy, Basic relationship among different	18

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

References:

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

Course No: 29	**Course Name:** Graph Theory					**Course Code:** SBSMAT 03 05 06 DSE 5106	
Batch: 2022-27	**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: 30	Course Name: Special Theory of Relativity					Course Code: SBSMAT 03 05 07 DSE 5106	
Batch: 2022-27	**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 Composition of parallel velocities, Length contraction, Time dilation, Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor.	18
Unit-III: Geometrical representation of space-time Four dimensional Minkowskian space-time of special relativity, Time-like, light-like and space-like intervals, Null cone, Proper time, World line of a particle, Four vectors and tensors in Minkowiskian space-time.	18
Unit-IV: Relativistic Mechanics Variation of mass with velocity. Equivalence of mass and energy. Transformation equations for mass momentum and energy. Energy-momentum four vector. Relativistic force and Transformation equations for its components. Relativistic equations of motion of a particle.	18
Unit-V: Electromagnetism Transformation equations for the densities of electric charge and current. Transformation equations for electric and magnetic field strengths. The Field of a Uniformly Moving Point charge. Forces and fields near a current carrying wire. Forces between moving charges. The invariance of Maxwell`s equations.	18

References:

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

SEMESTER – VI

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

<table>
<tr><td>Course No: 31</td><td colspan="3">Course Name: Complex Analysis</td><td colspan="4">Course Code: SBSMAT 03 06 01 C 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem:VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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.

<table>
<tr><td>Course No: 33</td><td colspan="3">Course Name: Discrete Mathematics</td><td colspan="4">Course Code: SBSMAT 03 06 01 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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 will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations, trees and graphs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through this course the students will be able to
• Learn about partially ordered sets, lattices and their types.
• Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.
• Solve real-life problems using finite-state and Turing machines.
• Assimilate various graph theoretic concepts and familiarize with their applications.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I: Partially Ordered Sets
Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.</td><td>18</td></tr>
<tr><td colspan="7">Unit-II: Lattices
Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.</td><td>18</td></tr>
</table>

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

References:

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

Course No: 34	**Course Name:** Wavelets and Applications					**Course Code:** SBSMAT 03 06 02 DSE 5106	
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** VI	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**

Course Objective	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.
Course Outcomes	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.

Content of Each Unit	**Hours**
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.	18
Unit-II: Haar Scaling Function and Wavelet, Time-Frequency Analysis Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions, Haar scaling function, Haar spaces: Haar space VO, general Haar space Vj; Haar wavelet,	18

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: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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>
<tr><td colspan="7">Unit-II: Number Theoretic Functions
Number theoretic functions for sum and number of divisors, Multiplicative function, The</td><td>18</td></tr>
</table>

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

References:

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

<table>
<tr><td>Course No: 36</td><td colspan="3">Course Name: Mathematical Finance</td><td colspan="4">Course Code: SBSMAT 03 06 04 DSE 5106</td></tr>
<tr><td rowspan="2">Batch: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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: 2022-27</td><td rowspan="2">Program: Integrated BSc-MSc (Mathematics)</td><td rowspan="2">Sem: VI</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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.

Course No: 38	Course Name: Advanced Mechanics					Course Code: SBSMAT 03 06 06 DSE 5106	
Batch: 2022-27	**Program: Integrated BSc-MSc (Mathematics)**	**Sem:** VI	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	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.						
Course Outcomes	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.						

Content of Each Unit	Hours
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.	18
Unit-II: Motion of a Rigid Body	18

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

References:

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

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

10. GENERIC ELECTIVE COURSES (GEC)

(Only for Other Departments)

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

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

Course No: 01	**Course Name:** Introductory Calculus and Analysis					**Course Code:** SBSMAT 03 01 01 GE 5106
Batch:	**Program: UG**	**Sem:** I	**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: 02</td><td colspan="3">Course Name: Basic Mathematics for Social Sciences</td><td colspan="4">Course Code: SBSMAT 03 01 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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</td><td>18</td></tr>
</table>

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

References:

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

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

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

References:

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

Course No: 04	**Course Name:** Vector Calculus				**Course Code:** SBSMAT 03 02 01 GE 5106		
Batch:	**Program: UG**	**Sem: II**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	The course provides an introduction to functions of several real variables and classical vector analysis. Topics discussed are: partial derivatives, gradients, line and surface integrals; vector valued functions, divergence, curl and flux of vector fields, the theorems of Green and Stokes, the divergence theorem, and applications						
Course Outcomes	After going through this course the students will be able to • Find the Triple product of Products and their Applications • Understand the concept of Line integral and Surface integral • Understand the concept of Tensor						

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

References:

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

<table>
<tr><td>Course No: 05</td><td colspan="3">Course Name: Mathematics for Chemists</td><td colspan="4">Course Code: SBSMAT 03 02 02 GE 5106</td></tr>
<tr><td rowspan="2">Batch:</td><td rowspan="2">Program: UG</td><td rowspan="2">Sem: II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>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 introduce the students to the exciting world of numerical analysis, differential equations and statistics.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completing this course, student is expected to learn the following:
• Learn the basics of numerical analysis, to calculate the errors in approximations and their properties.
• Understand the basics of differential equations to solve the first order linear differential equations and second order differential equations.
• Analyze the singular points, power series solution of differential equation at regular and irregular singular points, Bessel’s and Legendre’s equations and their solutions.
• Use the basics tools of statistics and by using these techniques to measures central tendency, learn Gaussian and Binomial distributions.</td></tr>
<tr><td colspan="7">Content of Each Unit</td><td>Hours</td></tr>
<tr><td colspan="7">Unit-I
Algebraic, transcendental functions, approximation, errors in approximation, absolute, relative and percentage errors, matrices and their properties, some special matrices, matrix algebra, the inverse matrix, linear transformations, orthogonal matrices and orthogonal transformations.</td><td>15</td></tr>
<tr><td colspan="7">Unit-II
Solution of differential equations, first-order linear equations- separable equations, homogeneous linear equations, non-homogeneous linear equations, second-order differential equations with constant coefficients, general solution, particular solution, linear equations in chemical kinetics, harmonic oscillator and
some other applications</td><td>15</td></tr>
</table>

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

References:

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

Course No: 06	**Course Name:** Numerical Methods					**Course Code:** SBSMAT 03 02 03 GE 3104	
Batch:	**Program: UG**	**Sem: II**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 06**
			5	1	0	6	**Total Hours: 90**
Course Objective	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.						
Course Outcomes	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						

Content of Each Unit	**Hours**
Unit I Nature of numerical computations: errors and their propagation	18
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.	18
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.	18

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

References:

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

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

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

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

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

References:

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

Course No: 08	Course Name: Differential Equations			Course Code: SBSMAT 03 03 02 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	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.						
Course Outcomes	After going through this course the students will be able to • Understand the genesis of ordinary differential equations. • Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order. • Know Picard's method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations. • Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations. • Formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.						

Content of Each Unit	**Hours**
Unit-I: First Order Differential Equations Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, differential Equations in which variables are separable, Homogeneous differential equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree differential equations solvable for x, y and p. Clairaut's form and singular solutions. Picard's method of successive approximations and the	18

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

References:

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

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

Course No: 09	Course Name: Complex Analysis				Course Code: SBSMAT 03 03 03 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	To providing the basic knowledge and to finds basic ideas of analysis for complex functions in complex variables with visualization through relevant practical's. Particular emphasis has been laid on Cauchy's theorems and series expansions.						
Course Outcomes	After going through this course the students will be able to • Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere. • Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations. • Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals. • Apply Liouville's theorem in fundamental theorem of algebra. • Understand the convergence, term by term integration and differentiation of a power series.						

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

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

References:

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

Course No: 10	**Course Name:** Introduction to Graph Theory					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 objective of the course is to introduce students with the fundamental concepts graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.						
Course Outcomes	After going through this course the students will be able to • Understand the concept of Graphs • Use the concept of planar graphs, trees and study for their properties • Analyze Matchings and coverings in Bipartite graphs						

Content of Each Unit	**Hours**
Unit I Graphs and Sub graphs:- Graphs and simple graphs, Graph isomorphism, The incidence and adjacency matrices, sub graphs, connected and bipartite graphs, walk, trail, path and cycles. Application: - The Shortest path problem, Dijkstra algorithm, Warshall Algorithm.	18
Unit-II: Trees:- Trees, Cut Edge and Bond, Cut vertex, spanning trees and Cayley's formula. The Connector Problem: Prim's Algorithm, Kruskal's Algorithm	18
Unit-III: Euler tour and Hamilton's Cycles, characterization of Eulerian graphs, a necessary and some sufficient characterizations of Hamiltonian graph. Closure and degree majorization and related results, Chinese Postman Problem	18
Unit-IV: Matchings: Theorem of Berge, Matchings and coverings in Bipartite graphs, Application: Hall's marriage theorem, Some Assignment Problems.	18
Unit-V: Application of Graphs. **Lab Component:** Implementation in C: Dijkstra Algorithm, Warshall Algorithm, BFS, DFS, Prims Algorithm, Kruskal Algorithm, Connectivity Algorithm, Flurey Algorithm.	18

References:

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

Course No: 11	**Course Name:** Optimization Techniques					**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	This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.						
Course Outcomes	After going through this course the students will be able to • Understand linear programming problems and to find their solutions by using different method. • Use the simplex method to solve linear programming • Solve the Dual of Linear Programing problem • Find optimal solution of transportation problems and assignment problems						

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

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

References:

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

Course No: 12	**Course Name:** Mathematical Modeling					**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 objectives of this course are to: • Enable students understand how mathematical models are formulated, solved and interpreted. • Make students appreciate the power and limitations of mathematics in solving practical real-life problems. • Equip students with the basic mathematical modelling skills						
Course Outcomes	After going through this course the students will be able to • Enable students understand how mathematical models are formulated, solved and interpreted. • Make students appreciate the power and limitations of mathematics in solving practical real-life problems • Understand the concept of Empirical Modeling with Data Fitting • Solve Mathematical models through Partial Differential equations						

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

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

References:

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

11. Teaching-Learning Process

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

12. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face-to-face classroom methods with computer-based activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and

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

Key features of Blended Learning

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

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

13. Assessment and Evaluation

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

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

14. Keywords

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

15. References

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

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

16. Appendix

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

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

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

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

(ii) Structure of Question Papers and Marks Distribution

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