CENTRAL UNIVERSITY OF HARYANA

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

(NAAC Accredited 'A' Grade)

CBCS, LOCF and NEP-2020 Based

Curriculum and Syllabi
of
M.Sc. Mathematics

(w.e.f. 2021-2022)

DEPARTMENT OF MATHEMATICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	√
Approval Date :	04.09.2021	20.09.2021	12.10.2021

TABLE OF CONTENTS

VISION AND MISSION

Vision and Mission of the University

Vision

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

Mission

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

Vision and Mission of the Department

Vision

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

Mission

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

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

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

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

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable

creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

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

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

ii) About the Mathematics

Mathematics is a powerful tool for global understanding and communication that organizes our lives and prevents chaos. Mathematics helps us understand the world and provides an effective way of building mental discipline. Mathematics encourages logical reasoning, critical thinking, creative thinking, abstract or spatial thinking, problem-solving ability, and even effective communication skills. Mathematics is necessary to understand the other branches of knowledge. All depend on mathematics in one way or another. There is no science, art, or specialty except mathematics was the key to it. The discipline and mastery of any other science or art are very much related to the size of mathematics.

iii) About the Programme (Nature, extent and aims)

A master's degree is a postgraduate degree for students who want to become more skilled or specialized in a particular discipline. While bachelor's and other undergraduate degrees typically give a relatively broad overview of a particular area of study, master's degrees tend to be more focused and allow students to develop the depth of their knowledge in a particular subject, putting them on the right course to become leaders in their fields.

The M.Sc. Mathematics programme, aims to build strong foundations in core areas of higher mathematics in both the pure and applied areas. It is meant for students who would typically take up careers involving mathematical research or mathematical skills – in academia or in industry. The training imparted to the students helps them master the art of problem solving, developing logical reasoning and computational capabilities which are essential traits in all walks of life. Additionally, the knowledge of mathematical modeling and computational training which the students acquire during the programme makes them highly sought after. In keeping with the demands of industry and academia, the syllabus is updated regularly, with inputs taken from various stakeholders including students, alumni and parents at different stages of the preparation of the syllabus.

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

Eligibility: For M.Sc. in Mathematics, the candidates with the following qualification are eligible:

B. A./B.Sc. (Hons.) in Mathematics from any recognized Indian or foreign university with 50% or above marks

OR

B.Sc./B. A. with Mathematics as one of the subject of study with 55% or above marks or equivalent grade in the aggregate

iv) Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a master degree in the Mathematics. M.Sc. Mathematics post-graduates of this department are expected to demonstrate knowledge of major portion of pure and applied mathematics and the ability to provide an overview of scholarly debates relating to Mathematics. Also it is expected that after the completion of this course they will be in a position to pursue their research in Mathematics. Along with mathematical skills, it is also expected that they will learn life skills of argumentation, communication and general social values which are necessary to live rich, productive and meaningful lives. The list below provides a synoptic overview of possible career paths provided by a postgraduate training in Mathematics:

1. Teaching
2. Research
3. Engineering
4. Computer programming (In different MNC's)
5. Statistician

6. Defense Research and Development Organization (DRDO) and Indian Space Research Organization (ISRO).
7. Can go for UPSC/Civil services exam.
8. Finance
9. Science and business

2. PROGRAMME OUTCOMES (POs)

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

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.

PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following specific outcomes by the end of program studies:

On successful completion of the M.Sc. Mathematics programme a student

Number	Programme Specific Outcomes
PSO-1	Will have a strong foundation in both pure and applied mathematics.
PSO-2	Will be able to apply mathematical skills for solving problems and for preparing various competitive exams.
PSO-3	Will be able to communicate mathematical knowledge effectively, in writing as well as orally.
PSO-4	Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.
PSO-5	Will have basic knowledge of programming and computational techniques as required for employment.
PSO-6	Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.
PSO-7	Will be able to locate and analyse the different mathematical texts with appropriate theoretical framework.
PSO-8	Have the knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in science, social science, engineering and technology.
PSO-9	Should be able to develop analytical skills, critical thinking, creativity, communication and presentation skills through assignments, seminar, project

	work.
PSO-10	Should be able to apply their skills and knowledge that translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

4. POSTGRADUATE ATTRIBUTES

No.	P.G. Attributes
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills
PGA-8	Life Skills
PGA-9	Life-long Learning
PGA-10	Global Competency

5. STRUCTURE OF MASTER'S COURSE

Types of Courses	**Nature**	**Total Credits**	**%**
Core Courses (CC)	Compulsory	65	67.01%
Elective Courses (EC)	Discipline Centric Elective Courses	24	24.74%
	Generic Elective Courses	08	8.25%
Skilled-based Courses/ Self-study based Courses	Skill Enhancement Elective Courses	00	

Note: The Scheme and Syllabus of the course are subject to change according to the UGC guidelines, NEP-2020 and University ordinance.

Course Type

Core Courses (CC)
Generic Elective Courses (GEC)
Discipline Centric Elective Courses (DCEC)
Skill Enhancement Elective Courses (SEEC)

Total Credit: 97, Semester-wise distribution of credits: 25+ 24 + 24 + 24

CORE COURSES (CC)

S.No.	Course Code	Course Title	L	T	P	Credit
1.	SBSMAT 01 01 01 C 3104	Real Analysis	3	1	0	4
2.	SBSMAT 01 01 02 C 3104	Algebra-I	3	1	0	4
3.	SBSMAT 01 01 03 C 3104	Complex Analysis	3	1	0	4
4.	SBSMAT 01 01 04 C 3104	Differential Equations	3	1	0	4
5.	SBSMAT 01 01 05 C 3104	Programming in C	3	1	0	4
6.	SBSMAT 01 01 06 C 0021	Lab Programming in C	0	0	2	1
7.	SBSMAT 01 02 01 C 3104	Linear Algebra	3	1	0	4
8.	SBSMAT 01 02 02 C 3104	Topology	3	1	0	4
9.	SBSMAT 01 02 03 C 3104	Numerical Analysis	3	1	0	4
10.	SBSMAT 01 02 04 C 0021	Lab for Numerical Analysis	0	0	2	1
11.	SBSMAT 01 02 05 C 2023	Typesetting in Latex	2	0	2	3
12.	SBSMAT 01 03 01 C 3104	Integral Equations and Calculus of Variation	3	1	0	4
13.	SBSMAT 01 03 02 C 3104	Functional Analysis	3	1	0	4
14.	SBSMAT 01 03 03 C 3104	Mathematical Statistics	3	1	0	4
15.	SBSMAT 01 03 04 C 0084	Seminar	0	0	8	4

16.	SBSMAT 01 04 01 C	Project/Dissertation	0	0	0	12

DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC)

(Offered to the students of M.Sc. Mathematics by the Department)

S.No.	Course Code	Course Title	L	T	P	Credit
1.	SBSMAT 01 02 01 DCEC 3104	Wavelet Analysis	3	1	0	4
2.	SBSMAT 01 02 02 DCEC 2124	Object Oriented Programming with C++	2	1	2	4
3.	SBSMAT 01 02 03 DCEC 3104	Information Theory	3	1	0	4
4.	SBSMAT 01 02 04 DCEC 3104	Operations Research	3	1	0	4
5.	SBSMAT 01 03 01 DCEC 3104	Applied Discrete Mathematics	3	1	0	4
6.	SBSMAT 01 03 02 DCEC 3104	Theory of Elasticity	3	1	0	4
7.	SBSMAT 01 03 03 DCEC 3104	Algebra – II	3	1	0	4
8.	SBSMAT 01 03 04 DCEC 3104	Fluid Dynamics	3	1	0	4
9.	SBSMAT 01 03 05 DCEC 3104	Fuzzy Set Theory	3	1	0	4
10.	SBSMAT 01 04 01 DCEC 3104	Differential Geometry	3	1	0	4
11.	SBSMAT 01 04 02 DCEC 3104	Mathematical Modelling	3	1	0	4
12.	SBSMAT 01 04 03 DCEC 3104	Advanced Numerical Analysis	3	1	0	4
13.	SBSMAT 01 04 04 DCEC 3104	Finite Element Methods	3	1	0	4
14.	SBSMAT 01 04 05 DCEC 3104	Advanced Complex Analysis	3	1	0	4
15.	SBSMAT 01 04 06 DCEC 3104	Introduction to Cryptography	3	1	0	4

16.	SBSMAT 01 04 07 DCEC 3104	Advanced Abstract Algebra	3	1	0	4
17.	SBSMAT 01 04 08 DCEC 3104	Measure Theory and Integration	3	1	0	4
18.	SBSMAT 01 04 09 DCEC 3104	Mechanics	3	1	0	4
19.	SBSMAT 01 04 10 DCEC 3104	Number Theory	3	1	0	4
20.	SBSMAT 01 04 11 DCEC 3104	Mathematics for Finance and Insurance	3	1	0	4

GENERIC ELECTIVE COURSES (GEC)

(Offered to PG students of other departments only)

S. No.	Course code	Course title	L	T	P	Credit
1.	SBSMAT 01 01 01 GEC 3104	Introduction to Mathematical Analysis	3	1	0	4
2.	SBSMAT 01 01 02 GEC 3104	Mathematics for Chemists	3	1	0	4
3.	SBSMAT 01 01 03 GEC 3104	Basic Mathematics for Social Science	3	1	0	4
4.	SBSMAT 01 02 01 GEC 2124	Typesetting in Latex	2	1	2	4
5.	SBSMAT 01 02 02 GEC 2124	Numerical Methods	2	1	2	4
6.	SBSMAT 01 02 03 GEC 3104	Discrete Mathematics	3	1	0	4

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

Skill Enhancement Elective Courses (SEEC)

(Skill Enhancement Elective Course**,** non-credit, only qualifying in nature): This may include a course based on Theoretical/Experimental/Computational Techniques/Methods. The department may offer more than one courses depending on specialization and strength of faculty members, and the student has to opt one of them.

S. No	Course Code	Course Title	L	T	P	Credit
1.	SBSMAT 01 04 01 SEEC 0120	Programming in MATLAB	0	1	2	0
2.	SBSMAT 01 04 02 SEEC 0120	Automata Theory	0	1	2	0
3.	SBSMAT 01 04 03 SEEC 0120	Artificial Intelligence and Machine Learning	0	1	2	0

6. LEARNING OUTCOME INDEX

6.1A Mapping of Courses with PSOs (first year)

Semester	PSOs ⇨	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
	Course No. ⇩										
I	1	√	√	√	√	x	√	√	√	√	√
	2	√	√	√	√	√	√	√	√	√	√
	3	√	√	√	√	√	√	√	√	√	√
	4	√	√	√	√	√	x	√	√	√	√
	5	√	√	√	√	√	√	x	√	√	√
	6	√	√	√	√	√	√	√	√	√	√
	7	√	√	√	√	x	√	√	√	√	√
	8	√	√	√	√	x	√	√	√	√	√
	9	√	√	√	√	√	√	√	√	√	√
II	10	√	√	√	√	√	√	√	√	√	√
	11	√	√	√	√	√	√	√	√	√	√
	12	√	√	√	√	√	√	√	√	√	√
	13	√	√	√	√	√	√	√	√	√	√
	14	√	√	√	√	√	√	√	x	x	√
	15	√	√	√	√	√	√	√	x	x	√
	16	√	√	√	√	√	√	√	√	√	√
	17	√	√	√	√	√	√	√	√	√	√
	18	√	√	√	√	√	√	√	√	x	√
	19	√	√	√	√	√	√	√	√	√	√
	20	√	√	√	√	√	√	√	√	√	√
	21	√	√	√	√	√	√	√	√	√	√

6.1B Mapping of Courses with PSOs (second year)

Semester	PSOs ⇨	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
	Course No. ⇩										
III	22	√	√	√	√	x	√	√	√	√	√
	23	√	√	√	√	√	√	√	x	√	√
	24	√	√	√	√	√	√	√	√	√	√
	25	√	√	√	√	√	√	√	√	√	√
	26	√	√	√	√	√	√	√	√	√	√
	27	√	√	√	√	x	√	√	√	√	√
	28	√	√	√	√	√	√	√	√	√	√
	29	√	√	√	√	√	x	√	√	√	√
	30	√	√	√	√	√	√	√	√	√	√
IV	31	√	√	√	√	√	√	√	√	√	√
	32	√	√	√	√	x	√	√	√	√	√
	33	√	√	√	√	√	√	√	√	√	√
	34	√	√	√	√	x	√	√	√	√	√
	35	√	√	√	√	√	√	√	√	√	x
	36	√	√	√	√	√	√	√	√	√	√
	37	√	√	√	√	√	√	√	√	√	√
	38	√	√	√	√	√	√	√	√	√	√
	39	√	√	√	√	√	√	√	√	√	√
	40	√	√	√	√	x	√	√	√	√	√
	41	√	√	√	√	√	√	√	√	√	√
	42	√	√	√	√	√	√	√	√	√	√
	43	√	√	√	√	√	√	√	√	√	√
	44	√	√	√	√	√	√	√	√	√	√
	45	√	√	√	√	√	√	√	√	√	√

7. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

SEMESTER-I

Total Credits: 25 (C: 21, GEC: 4)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses								
1	1	SBSMAT 01 01 01 C 3104	Real Analysis	3	1	0	4	4
2	2	SBSMAT 01 01 02 C 3104	Algebra-I	3	1	0	4	4
3	3	SBSMAT 01 01 03 C 3104	Complex Analysis	3	1	0	4	4
4	4	SBSMAT 01 01 04 C 3104	Differential Equations	3	1	0	4	4
5	5	SBSMAT 01 01 05 C 3104	Programming in C	3	1	0	4	4
6	6	SBSMAT 01 01 06 C 0021	Lab Programming in C	0	0	2	2	1
Generic Elective Courses (any two of 2 credits each or any one of 4 credits from the list*)**								
7		MOOC/GEC (to be taken from other departments)		-	-	-	-	4

GEC courses offered to PG students of other departments only

Course No.	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
7	SBSMAT 01 01 01 GEC 3104	Introduction to Mathematical Analysis	3	1	0	4	4
8	SBSMAT 01 01 02 GEC 3104	Mathematics for Chemists	3	1	0	4	4
9	SBSMAT 01 01 03 GEC 3104	Basic Mathematics for Social Science	3	1	0	4	4

Note: GEC courses will be offered only to those students who have studied mathematics only till 10^{th} standard.

SEMESTER-II

Total Credits: 24 (C: 16, DCEC: 4, GEC: 4)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses								
1	10	SBSMAT 01 02 01 C 3104	Linear Algebra	3	1	0	4	4
2	11	SBSMAT 01 02 02 C 3104	Topology	3	1	0	4	4
3	12	SBSMAT 01 02 03 C 3104	Numerical Analysis	3	1	0	4	4
4	13	SBSMAT 01 02 04 C 0021	Lab for Numerical Analysis	0	0	2	2	1
5	14	SBSMAT 01 02 05 C 2023	Typesetting in Latex	2	0	2	2	3
Discipline Centric Elective Courses								
6		MOOC/DCEC		-	-	-	-	4
Generic Elective Courses								
7		MOOC/GEC (to be taken from other departments)		-	-	-	-	4

GEC courses offered to PG students of other departments only

Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
15	SBSMAT 01 02 01 GEC 2124	Typesetting in LaTeX	2	1	2	4	4
16	SBSMAT 01 02 02 GEC 2124	Numerical Methods	2	1	2	4	4
17	SBSMAT 01 02 03 GEC 3104	Discrete Mathematics	3	1	0	4	4

Note: GEC courses will be offered only to those students who have studied mathematics upto 10+2 level.

DCEC courses for M.Sc. (Mathematics) students only

Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
18	SBSMAT 01 02 01 DCEC 3104	Wavelet Analysis	3	1	0	4	4
19	SBSMAT 01 02 02 DCEC 2124	Object Oriented Programming C++	2	1	2	4	4
20	SBSMAT 01 02 03 DCEC 3104	Information Theory	3	1	0	4	4
21	SBSMAT 01 02 04 DCEC 3104	Operations Research	3	1	0	4	4

SEMESTER-III

Total Credits: 24 (C:16, DCEC:8)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses								
1	22	SBSMAT 01 03 01 C 3104	Integral Equations and Calculus of Variation	3	1	0	4	4
2	23	SBSMAT 01 03 02 C 3104	Functional Analysis	3	1	0	4	4
3	24	SBSMAT 01 03 03 C 3104	Mathematical Statistics	3	1	0	4	4
4	25	SBSMAT 01 03 04 C 0084	Seminar	0	0	8	8	4
Discipline Centric Elective Courses								
5		MOOC/DCEC		-	-	-	-	4
6		MOOC/DCEC		-	-	-	-	4

GEC courses may be selected from GEC courses of semester I, if he/she has not studied that paper in Ist semester.

DCEC courses for M.Sc. (Mathematics) students only

Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
26	SBSMAT 01 03 01 DCEC 3104	Applied Discrete Mathematics	3	1	0	4	4
27	SBSMAT 01 03 02 DCEC 3104	Theory of Elasticity	3	1	0	4	4
28	SBSMAT 01 03 03 DCEC 3104	Algebra – II	3	1	0	4	4
29	SBSMAT 01 03 04 DCEC 3104	Fluid Dynamics	3	1	0	4	4
30	SBSMAT 01 03 05 DCEC 3104	Fuzzy Set Theory	3	1	0	4	4

SEMESTER-IV

Total Credits: 24 (C:12, DCEC:8)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
Core Courses								
1	31	SBSMAT 01 04 01 C	Project/Dissertation	-	-	-	12	12
Discipline Centric Elective Courses								
2		MOOC/DCEC		-	-	-	-	4
3		MOOC/DCEC		-	-	-	-	4
4		MOOC/DCEC		-	-	-	-	4
Discipline Centric Skill Based Courses								
5		SEEC		0	1	2	3	0

DCEC courses for M.Sc. (Mathematics) students only

Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
32	SBSMAT 01 04 01 DCEC 3104	Differential Geometry	3	1	0	4	4
33	SBSMAT 01 04 02 DCEC 3104	Mathematical Modelling	3	1	0	4	4
34	SBSMAT 01 04 03 DCEC 3104	Advanced Numerical Analysis	3	1	0	4	4
35	SBSMAT 01 04 04 DCEC 3104	Finite Element Methods	3	1	0	4	4
36	SBSMAT 01 04 05 DCEC 3104	Advanced Complex Analysis	3	1	0	4	4
37	SBSMAT 01 04 06 DCEC 3104	Introduction to Cryptography	3	1	0	4	4
38	SBSMAT 01 04 07 DCEC 3104	Advanced Abstract Algebra	3	1	0	4	4
39	SBSMAT 01 04 08 DCEC 3104	Measure Theory and Integration	3	1	0	4	4
40	SBSMAT 01 04 09 DCEC 3104	Mechanics	3	1	0	4	4
41	SBSMAT 01 04 10 DCEC 3104	Number Theory	3	1	0	4	4

42	SBSMAT 01 04 11 DCEC 3104	Mathematics for Finance and Insurance	3	1	0	4	4

OR

Total credits: 24 (C: 24)*

S. No.	Course	Course Code	L	T	P	Credits
1	Semester-long Project/Dissertation**	SBSMAT 01 04 02 C	-	-	-	24

***Allowed only on Departmental Committee Recommendations**

****** The date of final submission of Project/Dissertation report will be intimated to the students during third semester.**

SEEC (Skill Enhancement Elective Course**,** non-credit, only qualifying in nature): This may include a course based on Theoretical/Experimental/Computational Techniques/Methods. The department may offer more than one courses depending on specialization and strength of faculty members, and the student has to opt one of them. The course code may be given as: SBSMAT 01 04 0X SEEC 3100, X=1, 2, 3 ...etc.

Course No	Course Code	Course Title	L	T	P	Hrs/ Week	Total Credits
43	SBSMAT 01 04 01 SEEC 0120	Programming in MATLAB	0	1	2	3	0
44	SBSMAT 01 04 02 SEEC 0120	Automata Theory	0	1	2	3	0
45	SBSMAT 01 04 03 SEEC 0120	Artificial Intelligence and Machine Learning	0	1	2	3	0

8. COURSE-LEVEL LEARNING OUTCOMES

Course Structure

SEMESTER – I

<table>
<tr><td>Course No: 1</td><td colspan="3">Course Name: Real Analysis</td><td colspan="3">Course Code:
SBSMAT 01 01 01 C 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td></td><td></td><td></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course will develop a deep and rigorous understanding of real line $\mathbb{R}$ and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. The course will also develop the understanding of metric spaces and convergence, compactness, sequential compactness and connectedness in metric spaces. These concepts have wide range of applications in real life scenario.</td></tr>
</table>

Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand many properties of the real line and learn to define sequence in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$. **CO2:** Recognize bounded, convergent, divergent, Cauchy and monotonic sequences. To calculate the limit superior, limit inferior of sequences and limit of a bounded sequence. **CO3**: Recognize bounded variation, total variation, directional derivatives, partial derivative and derivative as a linear transformation. **CO4:** Understand many properties of metric spaces and convergence, compactness, sequential compactness and connectedness in metric spaces.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Real number system as complete ordered field, Archimedean property, supremum, infimum, Bolzano-Weierstrass property, sequence and series, convergence, limsup, liminf, continuity, uniform continuity.	15
II	**[Course Outcome (s) No. : 2]**	15

	Space of continuous functions, sequence and series of functions, uniform and pointwise convergence, Riemann sums and Riemann integral, Monotonic functions, types of discontinuity.	
III	**[Course Outcome (s) No. : 3]** Function of bounded variation, total variations, function of bounded variations expressed as difference of increasing functions, function of several variables, directional derivatives, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.	15
IV	**[Course Outcome (s) No. : 4]** Metric space and examples, open sets, closed sets, sequences in metric spaces and convergence, compactness, sequential compactness, continuity and compactness, Heine-Borel theorem, connected and path connected spaces, components, Continuity and connectedness.	15

Suggested Readings:

1. Walter, R. *Principles of Mathematical Analysis*. 3rdedition, McGraw-Hill, 2017.
2. Simmons, G. F. *Introduction to Topology and Modern Analysis*. McGraw-Hill Pvt. Ltd. 2016.
3. Kumaresan, S. *Topology of Metric Spaces*. Narosa Publishing House, 2011.
4. Terence T. *Analysis II*. Hindustan Book Agency, 2009.
5. Malik, S. C. and Arora, S. *Mathematical Analysis*. 2nd edition reprint. New Age International Publishers 2005.
6. Apostol, T. M. *Mathematical Analysis*. 2nd edition. *Wesley Publishing Co.* 2002.
7. Somasundram, D. and Chaudhary, B. *A First Course in Mathematical Analysis*. Narosa Publishing House, 1996.
8. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4th edition, New York, 1993.

Course No: 2	**Course Name:** Algebra-I				**Course Code:** SBSMAT 01 01 02 C 3104		
Batch: 2021-2023	**Programme:** M.Sc. Mathematics	**Semester:** I	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks			**Examination Duration:** 3 hours				
			Pre-requisite of course: Nil				

Course Objective	This course introduces the basic concepts of modern algebra such as groups and rings. The philosophy of this course is that modern algebraic notions play a fundamental role in mathematics itself and in applications to areas such as physics, computer science, economics and engineering.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Explain the fundamental concepts of advanced algebra such as groups and rings and their role in modern mathematics and applied contexts. **CO2:** Demonstrate accurate and efficient use of advanced algebraic techniques.

	CO3: Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from advanced algebra. **CO4:** Apply problem-solving using advanced algebraic techniques applied to diverse situations in physics, engineering and other mathematical contexts.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Groups, subgroup, normal subgroup, quotient group, homomorphism and isomorphism, cyclic group, permutation group, Cayley's theorem, Lagrange theorem	15
II	**[Course Outcome (s) No. : 2]** Class equation, Cauchy's theorem, Sylow p-subgroups and its applications,Sylow theorems, Direct product of groups, Structure of finitely generated abelian groups, description of group of order $p^2$and pq, where p and q are distinct primes (In general survey of groups upto order 15).	15

III	**[Course Outcome (s) No. : 3]** Rings, examples (including polynomial rings, formal power series rings, matrix rings and group rings, integral domains, division rings, fields), ideals, prime and maximal ideals,homomorphism and isomorphism of rings.	15
IV	**[Course Outcome (s) No. : 4]** Factorization in domains, Euclidean domains, principal ideal domains and unique factorizations domains, polynomial rings over UFD, polynomial rings over field, irreducibility criteria.	15

Suggested Readings:

1. Gallian, J. *A. Contemporary Abstract Algebra*. 9th edition. Cengage Learning, 2015.
2. Lang, S. *Algebra*. 3rd edition, Springer 2012.
3. Herstein, I. N. *Topics in Algebra*. 2ndedition. John Wiley and Sons, 2006.
4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra*. 2nd edition, Cambridge University Press, 2003.
5. Khanna, V. K. and Bhammbri, S. K. *A Course in Abstract Algebra*. Vikas Publishing house, 1999.
6. Cohn, P. M. *Algebra.* Vols. I & II, John Wiley & Sons, 1991.
7. Luther, S. and Passi, I. B. S. *Algebra.* Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I – 1996, Vol. II –1990).

<table>
<tr><td>Course No: 3</td><td colspan="3">Course Name: Complex Analysis</td><td colspan="4">Course Code:
SBSMAT 01 01 03 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">In this course students will learn about the algebra and geometry of complex numbers, analyticity, contour integration and conformal mapping.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Analyze the concept of differentiability, analyticity, Cauchy-Riemann equations and harmonic functions.

CO2: Compute complex contour integrals for their applications in Cauchy integral theorem.

CO3: Transform a functions into power series, categorize singularities and poles.

CO4: Understand the concept of bilinear transformation and conformal mapping.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five</td></tr>
</table>

questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**[Course Outcome (s) No. : 1]** Continuity and differentiability of complex function, Cauchy-Riemann equations, harmonic functions, analytic functions, analytic functions as mapping, the exponential function, trigonometric functions, hyperbolic functions, logarithmic functions, branch point, branch cut.	15
II	**[Course Outcome (s) No. : 2]** Power series representation of analytic functions, zeros of analytic functions, the index of a closed curve, Cauchy's theorem and integral formula, homotopic version of Cauchy's theorem and simple connectivity, counting zeros, Rouche's theorem, Liouville's Theorem, the open mapping theorem, Goursat theorem, Morera's theorem.	15
III	**[Course Outcome (s) No. : 3]** Taylor's series, Laurent's series, classification of singularities, residues, argument principle and their applications, contour integrals.	15
IV	**[Course Outcome (s) No. : 4]** Maximum modulus theorem, Schwarz's lemma and their applications. Mobius transformations, conformal mapping.	15

Suggested Readings:

1. Saff, E. B. and Snider, A. D. *Fundamentals of Complex Analysis with Applications to Engineering and Sciences*. Pearson Education, 2014.
2. Conway, J. B. Functions of One Complex Variable, Springer, 2012.
3. Mathews, J. H. and Howell, R. W. *Complex Analysis for Mathematics and Engineering.* Jones & Bartlett Publishers, 2012.
4. Brown, J. B. and Churchill, R. V. *Complex Variables and Applications*. 8th edition, Tata McGraw-Hill Education, 2009.
5. Ponnusamy, S. *Foundations of Complex Analysis.* Alpha Science International, 2005.
6. Copson, E. T. *Theory of Functions of Complex Variables*. Oxford University Press, 1970.

<table>
<tr><td>Course No: 4</td><td colspan="3">Course Name: Differential Equations</td><td colspan="4">Course Code:
SBSMAT 01 01 04 C 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td colspan="3"></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to introduce ordinary differential equations, fundamental theorems for existence and uniqueness and partial differential equations (PDE's). This course further explains the analytic techniques in computing the solutions of various ordinary differential equations and partial differential equations.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand ordinary differential equations of various types, their solutions and fundamental concepts about their existence.

CO2: Apply various power series methods to obtain series solutions of differential equations.

CO3: Solve the first-order linear and non-linear PDE's by using Lagrange's, Charpit's</td></tr>
</table>

	method and Jacobi's method respectively and understand Cauchy problem for first order PDE's. **CO4:** Determine the solutions of linear PDE's of second and higher order with constant coefficients, classify second order PDE's, solve standard PDE using separation of variable method and reduction to canonical form.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Preliminaries of ODE and PDE, existence and uniqueness theorems, existence of independent solutions, Wronskian, Abel's formula, trajectories, orthogonality of functions, orthonormal set of functions, singular solutions of first order ODEs, system of first order ODEs, critical points (saddle, node, spiral etc).	15
II	**[Course Outcome (s) No.: 2]** General theory of homogeneous and non-homogeneous linear differential equations, Sturm Liouville's boundary value problems, Green's function, regular and singular points, power series solution of differential equation at regular and	15

	irregular singular points, Bessel's and Legendre's equations and their solutions.	
III	**[Course Outcome (s) No.: 3]** Curves and surfaces in three dimensions, origin of PDEs, Lagrange's method, orthogonal surfaces, Charpit's method and Jacobi method, special types of first order PDEs, Cauchy problem for first order PDEs.	15
IV	**[Course Outcome (s) No.: 4]** Solutions of higher order linear PDEs, method of separation of variables for Laplace, heat, wave and diffusion equations, Canonical form and reduction to canonical form.	15

Suggested Readings:

1. Simmons, G. F. *Differential Equations with Applications and Historical Notes*. 2nd edition, Tata McGraw Hill, New Delhi, 2016.
2. Evans, L. C. *Partial Differential Equations*. 2nd edition, The Orient Blackswan, 2014.
3. Lebedev, N. N. *Special Functions and Their Applications*. Revised, Courier Corporation, 2012.
4. Ross, S. L. *Differential Equations*. 3rd edition, Wiley India, 2007.
5. Sneddon, I. N. *Elements of Partial Differential Equations*. Dover Publications, 2006.
6. Bell, W. W. *Special Functions for Scientists and Engineers*. Courier Corporation, 2004.
7. Raisinghania, M. D. *Advanced Differential Equations*. S. Chand & Company Ltd., New Delhi, 2001.
8. Reid, W. T. *Ordinary Differential Equations*. John Wiley and Sons, New York, 1971.

<table>
<tr><td>Course No: 5</td><td colspan="4">Course Name: Programming in C</td><td colspan="3">Course Code:
SBSMAT 01 01 05 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Mathematics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course objective is to familiarize the students with problem solving through C-programming. The course aims to give exposure to basic concepts of the C-programming. The lab component of this course is designed to provide hands-on-training with the concepts.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Classify and overview the programming languages and develop basic C programs, to defi data types and use them in simple data processing

CO2: Use various C-operators, expressions and input/output statements

CO3: Understand control flow using conditional branching and loop structures and the concept of array in problem solving</td></tr>
</table>

	CO4: Interprets the concepts of pointers, and classify functions and their usage

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** An overview of programming, programming languages, classification, C essentials program development, anatomy of a C function, variables, constants, expressions, assignment statements, formatting source files, continuation character, the pre-processor, scalar data types-declarations, different types of integers, different kinds of integer constants, floating point types, initialization, mixing types, explicit conversions-casts, data types	15
II	**[Course Outcome (s) No. : 2]** Operators and expressions - precedence and associatively, unary plus and minus operators, binary arithmetic operators, arithmetic assignment operators, increment	15

	and decrement operators, comma operator, relational operators, logical operators, bit manipulation operators, bitwise assignment operators, cast operator, size of operators, conditional operator, memory operators, input/output functions.	
III	**[Course Outcome (s) No. : 3]** Control Flow - conditional branching, the switch statement, looping, nested loops, break and continue statements, goto statement, infinite loops, Arrays - declaring an array, arrays and memory, initializing arrays, encryption and decryption, multidimensional arrays, strings.	16
IV	**[Course Outcome (s) No. : 4]** Functions - passing arguments, declarations and calls, recursion, the main ( ) function, passing arrays as function arguments. Pointers - pointer arithmetic, accessing array elements through pointers, passing pointers as function arguments, arrays of pointers.	14

Suggested Readings:

1. Balagurusamy, E. *Programming in ANSI C*. 3rdedition. TATA McGraw Hill, 2016.
2. Brain W. K. and Ritchie D. M. *C Programme Language*. 2nd edition, Pearson, 2015.
3. Darnell, P. A. and Margolis, P. E. *C: A Software Engineering Approach*. Narosa Publishing, House (Springer International Student Edition), 2012.
4. Yashavant, P. K. *Let Us C*. BPB Publication, 2008.
5. Byrons, G. *Programming With C*. 2nd edition, Schaum's Series, 1996.

<table>
<tr><td>Course No: 6</td><td colspan="4">Course Name: Lab Programming in C</td><td colspan="3">Course Code:
SBSMAT 01 01 06 C 0021</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme :

M.Sc. Mathematics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 2</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>1</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="6">The lab component of this course is designed to provides hands-on-training to the concepts of C-programming covered in theory classes.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="6">After completing this course, student is expected to learn the following:

CO1: Gain basic skills to write C-programs for simple mathematical problems

CO2: Able to write moderate C-programs for problem solving with the help of control flow statements, C-operators and functions.

CO3: Understand to implement various matrix operations with the help of Array and able to use string operation in C-programs

CO4: Develop the C-programs for some mathematical functions and real life problems</td></tr>
<tr><td colspan="7">COURSE SYLLABUS</td></tr>
<tr><td colspan="7">NOTE:</td></tr>
</table>

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**[Course Outcome (s) No. : 1, 2]** 1. Write a program (WAP) to understand concept of scanf and printf 2. WAP to swap two nos. using third variable 3. WAP to swap two nos. without using third variable. 4. WAP to convert temperature from Fahrenheit into Celsius. 5. WAP to find area and perimeter of rectangle. 6. WAP to find largest of two nos. 7. WAP to find largest of three nos. 8. WAP to find whether no. is even or odd 9. Using conditional operator find largest of two nos. 10. Using conditional operator find largest of three nos. 11. WAP that will take four digit no. and find sum of digits. 12. WAP to print 1 to 10 nos. 13. WAP to find roots of quadratic eq. 14. WAP to find sum of first n natural nos. 15. WAP to find average of n nos. 16. WAP to find reverse of no. 17. WAP for the function $f(x)$ using conditional operator	8

	$f(x) = \begin{cases} -1 & x < -5.0 \\ 0 & -5.0 \le x \le 5.0 \\ 1 & x > 5.0 \end{cases}$ 18. WAP to compute 1+1/2+1/3+1/4+--------+1/n 19. WAP to display nos. which are divisible by n b/w 1 & 1000. 20. WAP to convert lowercase text to uppercase	
II	**[Course Outcome (s) No. : 1, 2 , 4]** 21. WAP to generate Fibonacci series. 22. WAP to find nth term in Fibonacci series. 23. WAP to find factorial of no. using while, for, do-while loop. 24. WAP to check whether no. is prime or not 25. WAP to check whether no. is palindrome or not 26. WAP to display prime numbers in between two numbers *a* and *b*. 27. Print multiplication table of given no. using do while. 28. WAP to find whether given no. is Armstrong or not. 29. Write a menu driven program which has following option: factorial, prime, odd or even, exit 30. PRINT PATTERNs 1 1 * 23 12 *** 456 123 ***** 31. WAP to convert decimal no into binary and vice-versa. 32. WAP to print following pattern 1 232 34543 4567654	8

	33. WAP to print following pattern 1 101 10101 34. WAP to compute the following polynomial at any point $P(x) = x^3 – x^5 + x^7 – x^9 + ….n$ 35. $1/2(x\text{-}1/x) + 1/2(x\text{-}1/x)^2 + 1/2(x\text{-}1/x)^3 + …+n$ 36. $S= 1+x^2 + x^4 + x^6 + … +n$ 37. $S= x- x^3/3! + x^5/5! - x^7/7! + … n$ 38. Ackerman function:- $A(m,n) = n+1, m=0$ $A(m-1), m!=0, n=0$ $A(m-1, A(m,n-1)), m!=0, n!=0$ 39. WAP to find factorial of integer using recursion and without recursion 40. WAP to swap 2 nos. by call by reference	
III	**[Course Outcome (s) No. : 1, 2, 3]** 41. WAP to sort n numbers using array 42. To display nth no. stored in array 43. WAP to demonstrate what kind of operation can be performed on pointers. 44. WAP to pass 1-d array to function & using this function find 2 largest element 45. WAP to add two matrices. 46. WAP to multiply two matrices 47. WAP to find transpose of matrix 48. WAP to find greatest and smallest element in an array	8

	49. WAP to insert an element at a location in an array 50. WAP to delete an element from a location in an array 51. Linear and Binary search 52. Bubble sorting 53. WAP to find 2nd largest and 2nd smallest an element in an array 54. WAP to input string from terminal & display it 55. WAP to find reverse of string 56. Enter two strings & compare them using inbuilt function. 57. To convert string to lowercase to uppercase 58. String concatenation 59. Display ascii value of individual character of string 60. To find a character in string, display location & no. of occurrences.	
IV	**[Course Outcome (s) No. : 2, 3, 4]** 61. WAP C Program to Calculate the Simple Interest 62. WAP C Program to Find the GCD and LCM of Two Integers 63. WAP C Program to find HCF of a given Number using Recursion 64. WAP C Program to Calculate the Value of sin(x) 65. WAP C Program to Calculate the Value of cos(x) 66. WAP C Program to Calculate the Sum of cos(x) Series 67. WAP C Program to Find the Sum of First N Natural Numbers 68. WAP to find prime numbers in a given range 69. WAP C Program to Calculate the Mean, Variance & Standard Deviation 70. WAP C Program to Evaluate the given Polynomial Equation 71. WAP C program to Calculate the value of nCr 72. WAP C Program to Find & Display Multiplication Table 73. WAP to create, initialize, assign and access a pointer variable. 74. WAP to swap two numbers using pointers. 75. WAP to change the value of constant integer using pointers.	8

	76. WAP to print a string using pointer. 77. WAP to count vowels and consonants in a string using pointer. 78. WAP to read array elements and print with addresses. 79. WAP to print size of different types of pointer variables. 80. WAP to demonstrate example of array of pointers.	

Suggested Readings:

1. Balagurusamy, E. *Programming in ANSI C*. 3rd edition. TATA McGraw Hill, 2016.
2. Brain W. K. and Ritchie D. M. *C Programme Language*. 2nd edition, Pearson, 2015.
3. Darnell, P. A. and Margolis, P. E. *C: A Software Engineering Approach*. Narosa Publishing, House (Springer International Student Edition), 2012.
4. Yashavant, P. K. *Let Us C*. BPB Publication, 2008.
5. Byrons, G. *Programming With C*. 2nd edition, Schaum's Series, 1996.

Course No: 7	Course Name: Introduction to Mathematical Analysis						Course Code: SBSMAT 01 01 01 GEC 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	I					**4**
			3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** Nil

Course Objective	The course will develop a deep and rigorous understanding of sets and functions, and defining terms to prove the results on convergence of sequences and series, defining limit, continuity, differentiability and their geometrical representation. These concepts have wide range of applications in real life.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand many properties of sets and their relations, including finite set and countable set. **CO2:** Define functions and their classifications, including algebraic and transcendental functions and their geometric representations.

	CO3: Define sequences in term of functions from N to R and their convergences. **CO4:** Recognize limit, continuity and differentiability and their geometrical interpretation.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Sets, different kinds of sets, infinite and finite sets, countability, types of relations – void, universal, reflexive, symmetric, transitive and equivalence classes, complex numbers, graphic representation and properties, polar form of complex numbers, de Movier's theorem.	15
II	**[Course Outcome (s) No. : 2]** Functions, domain, co-domain, range, classification of real functions, algebraic and transcendental functions, even and odd functions, periodic functions, graphs of some important functions.	15

III	**[Course Outcome (s) No. : 3]** Definition of sequence and its convergence, series and convergence. Quadratic equations and roots, nature of roots.	15
IV	**[Course Outcome (s) No. : 4]** Limits, continuity and differentiability: Limit of a function, fundamental theorem on limits, methods of evaluating limits, existence of limit, left hand and right hand limit, continuity at a point, continuity in an interval, differentiability of a function at a point and in an interval, geometrical interpretation.	15

Suggested Readings:

1. Walter, R. *Principles of Mathematical Analysis*. 3rdedition, McGraw-Hill, 2017.
2. Ram, B. *Discrete Mathematics*. Pearson Education, 2012.
3. Malik, S. C. and Arora, S. *Mathematical Analysis*. 2ndedition. New Age International Publishers, 2005.
4. Somasundram, D. and Chaudhary, B. *A First Course in Mathematical Analysis*. Narosa Publishing House, 1996.
5. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4thcomplex an Edition, New York, 1993.

Course No: 8	**Course Name:** Mathematics for Chemists				**Course Code:** SBSMAT 01 01 02 GEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	I					**4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Nil					
Course Objective	The main objective of this course is to introduce the students to the exciting world of numerical analysis, differential equations and statistics.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Learn the basics of numerical analysis, to calculate the errors in approximations and their properties. **CO2:** Understand the basics of differential equations to solve the first order linear differential equations and second order differential equations. **CO3:** 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. **CO4:** Use the basics tools of statistics and by using these techniques to measures central						

	tendency, learn Gaussian and Binomial distributions**.**

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Algebraic, transcendental functions, approximation, errors in approximation, absolute, relative and percentage errors, matrices and their properties, some special matrices, matrix algebra, the inverse matrix, linear transformations, orthogonal matrices and orthogonal transformations.	15
II	**[Course Outcome (s) No. : 2]** Solution of differential equations, first-order linear equations- separable equations, homogeneous linear equations, non-homogeneous linear equations, second-order differential equations with constant coefficients, general solution, particular solution, linear equations in chemical kinetics, harmonic oscillator and some other applications	15

III	**[Course Outcome (s) No. : 3]** 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. Line integrals, double integrals, change of variables, polar coordinates, volume integrals, Laplacian operator, finite difference operators.	15
IV	**[Course Outcome (s) No. : 4]** Descriptive statistics, measures of central tendency, measures of dispersion, frequency and probability, permutations and combinations, binomial distribution, Gaussian distribution.	15

Suggested Readings:

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

<table>
<tr><td>Course No: 9</td><td colspan="5">Course Name: Basic Mathematics for Social Science</td><td colspan="2">Course Code:
SBSMAT 01 01 03 GEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of this course is to 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 of concepts and the development of intuition.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Explain the fundamental concepts of indices, logarithm and antilogarithm and their role in basic Mathematics for social science.

CO2: Demonstrate accurate and efficient use of set theory and Venn diagram.

CO3: Understand and use the terms: function, relation, series arithmetic, geometric progression, Permutations and Combinations.</td></tr>
</table>

	CO4: Understand the concepts and properties of limits, continuity and differentiation of a function, logical reasoning, probability and descriptive statistics.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** 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.	15
II	**[Course Outcome (s) No. : 2]** 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	15

	function; Greatest Integer function, Signum function), Graphical representation of functions.	
III	**[Course Outcome (s) No. : 3]** 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).	15
IV	**[Course Outcome (s) No. : 4]** Random experiment, sample space, events, mutually exclusive events. Independent and dependent Events, law of total probability, Bayes' Theorem. 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.	15

Suggested Readings:

1. Gill J. *Essential Mathematics for Political and Social Research*, Cambridge University Press, 2016.
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.
7. Namboodiri K. *Matrix Algebra: An Introduction*. Sage Publications # 38, 1994.

SEMESTER – II

<table>
<tr><td>Course No: 10</td><td colspan="3">Course Name: Linear Algebra</td><td colspan="4">Course Code:
SBSMAT 01 02 01 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">To give a brief introduction of vector spaces, linear transformation, matrix representation and various linear operators, which can be used by student for further applications in their respective fields of interest.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Describe the concepts of the terms basis, dimension, and apply these concepts to various vector spaces and subspaces.

CO2: Use the concept of linear transformations, matrix representation and change of basis, including kernel, range.

CO3: Understand the notion of bilinear forms, triangularization and primary</td></tr>
</table>

	decomposition theorem **CO4:** Compute inner products and determine orthogonality on vector spaces, applying Gram-Schmidt orthogonalization process to find the orthonormal basis.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** System of linear equation, vector spaces: definition and examples, subspaces, linear dependence, basis and dimension, sum and direct sum, quotient spaces, linear transformations: kernel and image of a linear transformation, rank and nullity of a linear transformation, matrix mappings.	15
II	**[Course Outcome (s) No. : 2]** Linear mappings and matrices: matrix representation of linear transformation, change of basis, similarity, polynomial of matrices, characteristic polynomial, Cayley-Hamilton theorem, diagonalization,	15

	minimal polynomial, companion matrix.	
III	**[Course Outcome (s) No. : 3]** Canonical and bilinear forms: triangular form, invariance, primary decomposition, Jordon canonical form, rational canonical form, bilinear and quadratic forms, reduction and classification of quadratic forms.	15
IV	**[Course Outcome (s) No. : 4]** Inner product space, examples and properties, norms and distances, orthonormal basis, the Gram-Schmidt orthogonalization, orthogonal complements, the adjoint of a linear operator on an inner product space, normal and self-adjoint operators, unitary operators.	15

Suggested Readings:

1. Hoffman, K. and Kunze, R. *Linear Algebra*. 2nd edition, Pearson India, 2015.
2. Axler, S. *Linear Algebra Done Right*. 2nd edition, Springer-Verlag, 2014.
3. Lang, S. *Linear Algebra*. 3rd edition, Springer-Verlag, New York, 2013.
4. Lipschutz, S. and Lipson, M. *Linear Algebra*. 3rd edition, Tata McGraw-Hill, 2005.
5. Friedberg, S. H., Insel, A. J. and Spence, L. E. *Linear Algebra*. 4th edition, 2002

<table>
<tr><td>Course No:
11</td><td colspan="4">Course Name: Topology</td><td colspan="3">Course Code:
SBSMAT 01 02 02 C 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week:
4</td></tr>
<tr><td colspan="3"></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours:
60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It is a central of modern analysis, and many further interesting generalizations of metric space have been developed.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Construct topological spaces from metric spaces and using general properties of neighbourhoods, open sets, close sets, basis and sub-basis

CO2: Apply the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems

CO3: Understand the concepts of countable spaces and separable spaces</td></tr>
</table>

	CO4: Learn the concepts and properties of the compact and connected topological spaces

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Definition and examples of topological spaces, basis and sub-basis, open sets, closed sets, interior points, limit points, boundary points, exterior points of a set, closure of a set, derived set, Hausdorff spaces.	15
II	**[Course Outcome (s) No. : 2]** Subspace topology, continuous functions, metric topology, convergence of sequences, sequential continuity, open and closed mappings, homeomorphism, pasting lemma, product topology, Tychonoff theorem.	15

III	**[Course Outcome (s) No. : 3]** Connectedness, continuity and connectedness, connected subsets of the real line, components, path connectedness, locally connected, locally path connected. Compactness and its characterizations, compact subspace of the real line, continuity and compact sets, compactness and finite intersection property.	15
IV	**[Course Outcome (s) No. : 4]** Countability and separation axioms, T_0, T_1, T_2, Lindelof spaces, regular and normal spaces, Urysohn Lemma, metrization theorems (Urysohnmetrization, Nagata-Smirnov metrization theorem), Tietze extension theorem, compactification.	15

Suggested Readings:

1. Joshi, K. D. *Introduction to General Topology*. 2nd edition, New Age International Private Limited, 2017.
2. Munkres, J. R. *Toplogy*. Pearson Education, 2017.
3. Simmons, G. F. *Introduction to Topology and Modern Analysis*. Tata McGraw-Hill Education, 2016.
4. Pervin, W. J. *Foundations of General Topology*. Academic Press, 2014.
5. Singh, T. B. *Elements of Topology*. CRC Press, Taylor Francis, 2013.
6. Kelley, J. L. *General Topology*. 2nd edition, Springer, New York, 1991.

<table>
<tr><td>Course No: 12</td><td colspan="3">Course Name: Numerical Analysis</td><td colspan="4">Course Code:
SBSMAT 01 02 03 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</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>
</table>

Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Overview the errors in computation and their measurements **CO2:** Apply numerical techniques to obtain approximate solutions to otherwise intractable mathematical problems **CO3:** Learn numerical technique to find the solutions of nonlinear equations, system of linear equations, interpolation problems, numerical differentiations and integration, Initial and boundary value problems **CO4:** Familiarized the students with convergence, advantages and limitations of these numerical techniques

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2, 3, 4]** Errors in approximation, absolute, relative and percentage errors, round-off error. Solution of algebraic and transcendental equations: bisection method, Regula Falsi method, Secant method, method of iteration, Newton Raphson method,	16

	order of convergence. Systems of simultaneous equations: Gauss elimination method, Gauss Jordon method, LU decomposition method, Iterative methods: Jacobi method and Gauss-Seidel method.	
II	**[Course Outcome (s) No. : 2, 3, 4]** Finite differences, Interpolation techniques for equal intervals-Newton forward and backward, Gauss forward, Gauss Backward, Stirling, Bessel formulae. Interpolation with unequal intervals-Newton's divided difference method, Lagrange method. Hermite interpolation, Power method for eigenvalue problem.	14
III	**[Course Outcome (s) No. : 2, 3, 4]** Numerical differentiation using Newton forward and backward formulae. Numerical integration: Newton-Cotes formulas, trapezoidal rule, Simpson rule, Gauss-Legendre, Gauss-Chebyshev formulas, Romberg's integration, Curve fitting: straight line fitting, parabolic curve fitting, fitting of exponential curve, fitting of other curves. Cubic splines	16
IV	**[Course Outcome (s) No. : 2, 3, 4]** Solution of ordinary differential equations: Taylor series method, Picard's method, Euler method, Euler modified method, Runge–Kutta methods, Milne's and Adam's predictor and corrector methods. Finite difference method for boundary value problems.	14

Suggested Readings:

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge Universi Press, 2019.

2. Thangaraj, P. *Computer Oriented Numerical Methods*. PHI Learning Pvt. Ltd, 2013.

3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. *Numerical Methods for Scientific & Engineering Computation*. New Age International, 2012.

4. Burden R. L. and Faires J. D. *Numerical Analysis*. 9th Edition, Cengage Learning, 2011.

5. Chapra, S. C. and Canale, R. P. *Numerical Methods for Engineers*. McGraw Hill, International Edition, 1998.

6. Mathews, J. H. *Numerical Methods for Mathematics, Science and Engineering*. Prentice- Hall, International Editions, 1992.

<table>
<tr><td>Course No:
13</td><td colspan="3">Course Name: Lab For Numerical Analysis</td><td colspan="4">Course Code:
SBSMAT 01 02 04 C 0021</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

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

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The lab component of this course is aim to design the programs on C/C++/MATLAB for various numerical methods covered in the course.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Write efficient and well documented codes for various numerical methods and present outputs in an informative way

CO2: Able to solve problems covered in the theory paper (Numerical Analysis) with more accuracy using computer code.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:
Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I</td></tr>
</table>

will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**[Course Outcome (s) No. : 1, 2]** 1. To detect the interval(s) which contain(s) root of equation f(x)=0 and implement bisection method to find root of f(x)=0 in the detected interval. 2. To find the root of f(x)=0 using Regula Falsi and Secant methods 3. To find the root of f(x)=0 using Newton -Raphson and fixed point iteration methods. 4. To solve linear system of equations using Gauss elimination (without pivoting) method.	8
II	**[Course Outcome (s) No. : 1, 2]** 5. To solve linear system of equations using Gauss Jordan method. 6. To solve linear system of equations using Jacobi and Gauss-Seidel methods 7. To compute the intermediate value using the Newton's forward	8

	difference interpolation formula. **8.** To implement Lagrange interpolation formula	
III	**[Course Outcome (s) No. : 1, 2]** 9. To compute Newton divided difference (NDD) table and use it compute interpolating value with NDD formula. 10. To integrate a function numerically using trapezoidal and Simpson's rules. 11. To compute integration numerically from a data set using trapezoidal and Simpson's rules 12. To fit a straight line to a given data set	8
IV	**[Course Outcome (s) No. : 1, 2]** 13. To solve the initial value problem using Euler and modified Euler's methods. 14. To apply Milne's and Adam's predictor and corrector methods for solution of initial value problems 15. To solve the initial value problem using Runge-Kutta methods. 16. To apply finite difference method for boundary value problems	8

Suggested Readings:

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge University Press, 2019.

   General Resources: C-Programs available online at https://www.cambridge.org/

2. Thangaraj, P. *Computer Oriented Numerical Methods*. PHI Learning Pvt. Ltd, 2013.

3. Burden R.L. and Faires J. D. *Numerical Analysis*. 9th Edition, Cengage Learning, 2011.

4. Chapra, S. C. and Canale, R. P. *Numerical Methods for Engineers*. McGraw Hill, International Edition, 1998.

5. Mathews, J. H. *Numerical Methods for Mathematics, Science and Engineering*. Prentice- Hall, International Editions, 1992.

<table>
<tr><td>Course No: 14</td><td colspan="5">Course Name: Typesetting In Latex</td><td colspan="2">Course Code:
SBSMAT 01 02 05 C 2023</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td></td><td></td><td></td><td>2</td><td>0</td><td>2</td><td>3</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and drawing graphs.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Typeset mathematical formulas, use nested list, tabular & array environments.

CO2: Create or import graphics.

CO3: Use alignment command and multiline formulas, bibliography and citation, making index and glossary.

CO4: Use beamer to create presentation and typeset mathematical Projects, Dissertation, Thesis and Books.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 3]** Preparing an input file, sentences and paragraphs, the document class, sectioning, display material, running Latex, changing the type style, producing mathematical symbols and mathematical formulae, arrays, delimiters, multiline formulae, putting one thing on other, spacing in math mode.	15
II	**[Course Outcome (s) No. : 2, 3]** Defining command and environments, producing and including graphics in a Latex file, figures and other floating bodies, lining it up in columns, table of content, cross-reference, bibliography and citation, making index and glossary, slides, overlays and notes, letters.	15

III	**[Course Outcome (s) No. :1, 3, 4]** Design it yourself: document class, page style, title page, customizing the style, line and page breaking, numbering, length, spaces and boxes, formatting with boxes, centring and flushing, list making environments, changing font type size and special symbols, picture, picture environments, picture objects, text, boxes, straight lines, arrow, stacks, circles, oval, framing, curve, grid, repeat patterns.	15
IV	**[Course Outcome (s) No. : 3, 4]** Making presentation slides in beamer class Latex, various styles in beamer presentation, dynamic slides. postscript macros for generic tex (pstrix): arguments, dimension, coordinates, angles, line styles, fill styles, custom styles, custom graphics, picture tools, text tricks, node and connection special tricks, basics of mathjax, mathjax configuration options.	15

Suggested Readings:

1. Kottwitz, S. *LaTeX Beginner's Guide*. Packt Publishing Ltd., UK, 2011.
2. Leslie L. *A Document Preparation System User's Guide and Reference Manual*, Addison-Wesley Publishing Company, 2001.
3. Tantau,T. *User Guide to the Beamer Class*, http://latex-beamer.sourceforge.net.
4. Oetiker,T. *The Not So Short Introduction to LATEX2E*, https://tobi.oetiker.ch/lshort/lshort.pdf.

Course No: 15	Course Name: Typesetting in Latex				Course Code: SBSMAT 01 02 01 GEC 2124		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	II					**4**
			2	0	2	3	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Nil					
Course Objective	The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and drawing graphs.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Typeset mathematical formulas, use nested list, tabular & array environments. **CO2:** Create or import graphics. **CO3:** Use alignment command and multiline formulas, bibliography and citation, making index and glossary. **CO4:** Use beamer to create presentation and typeset mathematical Projects, Dissertation, Thesis and Books.						

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I

will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 3]** Preparing an input file, sentences and paragraphs, the document class, sectioning, display material, running Latex, changing the type style, producing mathematical symbols and mathematical formulae, arrays, delimiters, multiline formulae, putting one thing on other, spacing in math mode.	15
II	**[Course Outcome (s) No. : 2, 3]** Defining command and environments, producing and including graphics in a Latex file, figures and other floating bodies, lining it up in columns, table of content, cross-reference, bibliography and citation, making index and glossary, slides, overlays and notes, letters.	15
III	**[Course Outcome (s) No. :1, 3, 4]** Design it yourself: document class, page style, title page, customizing the style, line and page breaking, numbering, length, spaces and boxes, formatting with boxes, centring and flushing, list making environments, changing font type size and special symbols, picture, picture environments, picture objects, text, boxes, straight lines, arrow, stacks, circles, oval, framing, curve, grid, repeat patterns.	15
IV	**[Course Outcome (s) No. : 3, 4]** Making presentation slides in beamer class Latex, various styles in beamer presentation, dynamic slides. postscript macros for generic tex (pstrix): arguments, dimension, coordinates, angles, line styles, fill styles, custom styles, custom graphics, picture tools, text tricks, node and connection special tricks,	15

	basics of mathjax, mathjax configuration options.	

Suggested Readings:

5. Kottwitz, S. *LaTeX Beginner's Guide*. Packt Publishing Ltd., UK, 2011.
6. Leslie L. *A Document Preparation System User's Guide and Reference Manual*, Addison-Wesley Publishing Company, 2001.
7. Tantau,T. *User Guide to the Beamer Class*, http://latex-beamer.sourceforge.net.
8. Oetiker,T. *The Not So Short Introduction to LATEX2E*, https://tobi.oetiker.ch/lshort/lshort.pdf.

<table>
<tr><td>Course No: 16</td><td colspan="3">Course Name: Numerical Methods</td><td colspan="4">Course Code:
SBSMAT 01 02 02 GEC 2124</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>2</td><td>1</td><td>2</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The 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>
</table>

Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Overview the errors in computation and their measurements **CO2:** Apply numerical techniques to obtain approximate solutions to otherwise intractable mathematical problems **CO3:** Learn numerical technique to find the solutions of nonlinear equations, system of linear equations, interpolation problems, numerical differentiations and integration, Initial and boundary value problems **CO4:** Familiarized the students with convergence, advantages and limitations of these numerical techniques

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2, 3, 4]** Errors in approximation, absolute, relative and percentage errors, round-off error. Solution of algebraic and transcendental equations: bisection method, Regula Falsi method, Secant method, method of iteration, Newton Raphson method, order of	16

	convergence. Systems of simultaneous equations: Gauss elimination method, Gauss Jordon method, LU decomposition method, Iterative methods: Jacobi method and Gauss-Seidel method.	
II	**[Course Outcome (s) No. : 2, 3, 4]** Finite differences, Interpolation techniques for equal intervals-Newton forward and backward, Gauss forward, Gauss Backward, Stirling, Bessel formulae. Interpolation with unequal intervals-Newton's divided difference method, Lagrange method. Hermite interpolation, Power method for eigenvalue problem.	14
III	**[Course Outcome (s) No. : 2, 3, 4]** Numerical differentiation using Newton forward and backward formulae. Numerical integration: Newton-Cotes formulas, trapezoidal rule, Simpson rule, Gauss-Legendre, Gauss-Chebyshev formulas, Romberg's integration, Curve fitting: straight line fitting, parabolic curve fitting, fitting of exponential curve, fitting of other curves. Cubic splines	16
IV	**[Course Outcome (s) No. : 2, 3, 4]** Solution of ordinary differential equations: Taylor series method, Picard's method, Euler method, Euler modified method, Runge–Kutta methods, Milne's and Adam's predictor and corrector methods. Finite difference method for boundary value problems.	14

***Suggested Readings*:**

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge Universi Press, 2019.

2. Thangaraj, P. *Computer Oriented Numerical Methods*. PHI Learning Pvt. Ltd, 2013.

3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. *Numerical Methods for Scientific & Engineering Computation*. New Age International, 2012.

4. Burden R.L. and Faires J. D. *Numerical Analysis*. 9th Edition, Cengage Learning, 2011.

5. Chapra, S. C. and Canale, R. P. *Numerical Methods for Engineers*. McGraw Hill, International Edition, 1998.

6. Mathews, J. H. *Numerical Methods for Mathematics, Science and Engineering*. Prentice- Hall, International Editions, 1992.

<table>
<tr><td>Course No: 17</td><td colspan="5">Course Name: Discrete Mathematics</td><td colspan="2">Course Code:
SBSMAT 01 02 03 GEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of the course is to introduce students with the fundamental concepts in Boolean algebra 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 completing this course, student is expected to learn the following:

CO1: Understand the concepts of Mathematical Logic: Statement and notations, proposition, Hasse diagram, function and Pigeon hole principle

CO2: Learn the basic concepts of Boolean algebra, lattice, logical gates and relations of Boolean function

CO3: Analyze the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices</td></tr>
</table>

	CO4: Use the properties of trees to find a minimal spanning tree for a given weighted graph and understand Eulerian and Hamiltonian graphs

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Mathematical Logic: Statement and notations, proposition and logic operations, connectives(conjunction, disjunction, negation), statement formulas and truth tables, propositions generated by set, equivalence of formulas and implication laws of logic, mathematical systems, propositions over a universe, principal of mathematical induction, variables, quantifiers.	15
II	**[Course Outcome (s) No. : 2]** Relation and Function: Binary relations, properties of binary relation in a set, equivalence relations, composition of binary relations, partial ordering and partial order set, Hasse diagram, function and Pigeon hole principle, recursion definition, many faces of recursion, recurrence relations, common recurrence	15

	relations, generating functions and their solutions.	
III	**[Course Outcome (s) No. : 3]** Boolean algebra: Posets, lattice and basic properties of Boolean algebraic, principle of duality, distributive and complemented lattices, uniqueness of finite Boolean algebra, Boolean functions and Boolean expressions, normal forms of Boolean expression and simplifications of Boolean expressions, basic circuits and theorems, logical gates and relations of Boolean function.	15
IV	**[Course Outcome (s) No. : 4]** Graph theory: Basic terminology of graph theory, paths, circuits, graph connectivity, Eulerian paths, multigraphs, weighted graphs. Trees, spanning trees, binary trees, rooted trees, planar graphs, Eulers theorem. The Konigsberg bridge problem and Eulerian graphs, Hamiltonian graphs.	15

***Suggested Readings*:**

1. Ram, B. Discrete Mathematics, Pearson Education, 2012.
2. Rosen, K. H. *Discrete Mathematics and Its Applications*. 7th edition, Tata McGraw Hill, 2011.
3. Khanna, V. K. *Lattices and Boolean Algebras*. PHI Publication, 2004.
4. Lipschutz, S., Lipson, M.L. and Patil, V.H. *Discrete Mathematics.* Schaum's Outline Series, Tata McGraw-Hill Education, 2006.
5. Liu, C. L. *Elements of Discrete Mathematics.* Tata McGraw Hill, 2000.
6. Trembley, J. P. and Manohar, R. *A First Course in Discrete Structure with applications to Computer Science*. Tata McGraw Hill, 1999.

<table>
<tr><td>Course No: 18</td><td colspan="3">Course Name: Wavelet Analysis</td><td colspan="4">Course Code:
SBSMAT 01 02 01 DCEC 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td colspan="3"></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course aim is to introduce a flexible system which provide stable reconstruction and analysis of functions (signals) and the construction of variety of orthonormal bases by applying operators on a single wavelet function.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the approximation of functions (signals) by frame theory.

CO2: Use the applications of frames in stable analysis and decompositions of functions.

CO3: Learn the applications of wavelets in the construction of orthonormal bases by wavelets.

CO4: Analyse different types of transforms in term of operators.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td colspan="8">NOTE:</td></tr>
</table>

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	**[Course Outcome (s) No. : 1]** Review of inner product spaces, orthonormal systems, frames in C^n, frames algorithms, frames and Bessel sequences in infinite dimensional Hilbert spaces, frame sequence, the Gram matrix associated with Bessel sequences.	15
II	**[Course Outcome (s) No. : 2]** Frames and operators, characterization of frames, dual frames, tight frames. Riesz bases, frames versus Riesz bases, conditions for a frame being a Riesz basis, frames containing a Riesz basis, perturbation of frames.	15
III	**[Course Outcome (s) No. : 3]** Wavelets, Haar wavelets, basic properties of the Haar scaling function, Haar decomposition and reconstruction algorithms, the Daubechies wavelets, wavelet bases, scaling function. multire solution analysis (MRA), construction of wavelets from MRA.	15
IV	**[Course Outcome (s) No. : 4]** Windowed Fourier transform (WFT), continuous Fourier transform (CFT), continuous wavelet transform (CWT), comparison between CFT and CWT, continuous wavelet transform as an operator, inversion formula for continuous wavelet transform.	15

***Suggested Readings*:**

1. Boggess, A. and Narcowich, F.J. *A First Course in Wavelets and Fourier Analysis*. John Wiley & amp; Sons, 2010.
2. Mallat, S. *A Wavelet Tour of Signal Processing*. Academic Press, 2009.
3. Han, D., Kornelson, K., Larson, D. and Weber, E. *Frames for Undergraduates*, Student Math. Lib (AMS) Vol. 40, 2007.
4. Christensen, O. *An Introduction to Frames and Riesz Bases*. Birkhauser, 2003.
5. Harnendez, E. and Weiss, G. *A First Course on Wavelets*, CRC Press, 1996.

<table>
<tr><td>Course No: 19</td><td colspan="4">Course Name: Object Oriented Programming With C++</td><td colspan="3">Course Code:
SBSMAT 01 02 02 DCEC 2124</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week:
5</td></tr>
<tr><td>2</td><td>1</td><td>2</td><td>4</td><td>Total Hours:
75</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Programming in C</td></tr>
<tr><td>Course Objective</td><td colspan="7">After familiarizing the students with problem solving through C-programming, this course aims to give exposure to basic and advanced concepts of Object-Oriented Programming (OOP). The objective of course is to develop programming skills of students, using object oriented programming concepts, learn the concept of class and object using C++ and develop classes for simple applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Identify importance of OOP and able to differentiate between structured oriented and OOP features

CO2: Develop simple C++ programs and compiling and executing in different environment</td></tr>
</table>

	CO3: Develop programs using functions, objects and classes **CO4:** Interprets the concept of constructors and destructors. Operator overloading and type conversions. Inheritance and polymorphism concepts of OOP **CO5:** Acquire knowledge of stream, i/o console, and file handling

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2]** Basic concepts of Object-Oriented Programming (OOP). Advantages and applications of OOP. Object-oriented languages. Introduction to C++. Structure of a C++ program. Creating the source files. Compiling and linking. C++ programming basics: input/output, data types, operators, expressions, control structures, library functions.	20
II	**[Course Outcome (s) No. : 1, 2, 3]** Functions in C++ : Passing arguments to and returning values from functions, inline functions, default arguments, function overloading. Classes and objects: Specifying and using class and object, arrays within a class, arrays of objects, object as a function arguments, friendly functions, pointers to members.	18

III	**[Course Outcome (s) No. : 1, 2, 4]** Constructors and destructors. Operator overloading and type conversions. Inheritance: Derived class and their constructs, Overriding member functions, class hierarchies, public and private inheritance levels. Polymorphism, pointers to objects, this pointer, pointers to derived classes, virtual functions.	19
IV	**[Course Outcome (s) No. : 1, 2, 5]** Streams, stream classes, unformatted i/o operations, formatted console i/o operations, managing output with manipulators. Classes for file stream operations, opening and closing a file. File pointers and their manipulations, random access. Error handling during file operations, command-line arguments. Exceptional handling.	18

***Suggested Readings*:**

1. Yashavant, P. K. *Let Us C++*. BPB Publication, 2020.
2. Balagrusamy, E. *Object Oriented Programming with C++*. 2nd edition, Tata McGraw Hill Pub. Co, 2013.
3. Lafore, R. *Object Oriented Programming in C++*. 4th edition, Pearson, 2008.
4. Gottfried, B. S. *Object Oriented Programming using C++*. Schaum's Outline Series, Tata McGraw Hill Pub. Co., 2000.
5. Barakaki, J. N. *Object Oriented Programming using C++*. Prentice Hall of India, 1996.

<table>
<tr><td>Course No: 20</td><td colspan="3">Course Name: Information Theory</td><td colspan="4">Course Code:
SBSMAT 01 02 03 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to introduce basic and advanced topics in information theory. This course further explains the different types of entropies, codes, discrete and continuous channels and their applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the basic concepts of information theory, different types of entropies with their properties and applications.

CO2: Analyse how different coding techniques will perform in different situations.

CO3: Understand about discrete channels and their properties with applications.

CO4: Understand about continuous channels and their properties with applications.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Measure of information – axioms for a measure of uncertainty, the Shannon entropy and its properties. joint and conditional entropies, transformation and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.	15
II	**[Course Outcome (s) No.: 2]** Noiseless coding - ingredients of noiseless coding problem, uniquely decipherable codes, necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.	15
III	**[Course Outcome (s) No.: 3]** Discrete memory less channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes the ideal observer, the fundamental theorem of information theory and its strong and weak converses.	15

IV	**[Course Outcome (s) No.: 4]** Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-discrete Gaussian channel, the time-continuous Gaussian channel, band-limited channels.	15

***Suggested Readings*:**

1. Ash, R. B. *Information Theory*. Courier Corporation, 2012.
2. Reza, F.M. *An Introduction to Information Theory*. Courier Corporation, 2012.
3. Hankerson, H. D., Harris, G. A. and Johnson, P. D. *Introduction to Information Theory and Data Compression*. Chapman and Hall/CRC, 2nd edition, 2003.
4. Aczel, J. and Daroczy, Z. *On Measures of Information and their Characterizations.* Academic Press, New York, 1975.

<table>
<tr><td>Course No: 21</td><td colspan="3">Course Name: Operations Research</td><td colspan="4">Course Code:
SBSMAT 01 02 04 DCEC 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

II</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td></td><td></td><td></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand linear programming problems and to find their solutions by using different method.

CO2: Find optimal solution of transportation problems and assignment problems

CO3: Understand and solve different queuing models.</td></tr>
</table>

	CO4: Find optimal solution of linear programming model using Game Theory. Also learn about sequencing problems.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Operations research: origin, definition and scope. linear programming: formulation and solution of linear programming problems by graphical, simplex methods, Big-M and two phase methods, degeneracy, duality in linear programming, sensitivity analysis.	15
II	**[Course Outcome (s) No.: 2]** Transportation problems: basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem. Assignment problems: solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew	15

	assignment problems.	
III	**[Course Outcome (s) No.: 3]** Queuing models: basic components of a queuing system, general birth-death equations, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/M/C/k)	15
IV	**[Course Outcome (s) No.: 4]** Game theory: two persons zero sum game, game with saddle points, rule of dominance; algebraic, graphical and linear programming, concept of mixed strategy. sequencing problems: processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.	15

***Suggested Readings*:**

1. Sharma, S. D. Operation Research, Kedar Nath Ram Nath Publications, 2012.
2. Swarup, K. and Gupta, P.K. Operations Research. S. Chand publisher, 2010.
3. Taha, H. A. Operation Research: An Introduction.9th edition, Pearson, 2010.
4. Gupta, P.K. and Hira, D.S. Introduction to Operations Research, S. Chand & Co. 2008.
5. Sharma, J. K., Mathematical Model in Operation Research, Tata McGraw Hill, 1989.

SEMESTER – III

Course No: 22	**Course Name:** Integral Equations and Calculus of Variation				**Course Code:** SBSMAT 01 03 01 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Mathematics	III					
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100		**Examination Duration:** 3 hours					
CIE: 30 Marks **TEE:** 70 Marks		**Pre-requisite of course:** Nil					
Course Objective	In this course we study in detail about integral equations and calculus of variations. Integral equations find numerous applications in real life physical problems. The main objective of the course is to make the learner familiarize with resolvent kernel, successive approximation, solution of homogeneous Fredholm integral equation for solving integral equations and variational problems. Differential equations can be studied for their solutions by transforming them into integro-differential equations using Laplace transform.						

Course Outcomes :	After completing this course, student is expected to learn the following: **CO1:** Use the concept of different kernels and techniques for solving various kinds of integral equations. **CO2:** Find the solutions of Volterra integral equations using Neumann series method. **CO3:** Understand the relation between differential and integral equations. **CO4:** Learn about the formulation of variational problems, the variation of a functional and its properties, extremum of functional, sufficient condition for an extremum.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Linear integral equations: Volterra integral equations, Fredholm integral equations, some basic identities, types of kernels: symmetric kernel, separable kernel, iterated kernel, resolvent kernel. Initial value problems reduced to Volterra integral equations, solution of Volterra integral equation using: resolvent kernel, successive approximation, neumann	15

	series method.	
II	**[Course Outcome (s) No. : 2]** Boundary value problems reduced to Fredholm integral equations, solution of Fredholm integral equations using separable kernel, resolvent kernel,methods of successive approximation and successive substitution to solve Fredholm equations of second kind, solution of homogeneous Fredholm integral equation, eigen values, eigen vectors.	15
III	**[Course Outcome (s) No. : 3]** Integral transforms for solving integral equations, basic properties of Laplace transforms, solution of Abel's equation using Laplace transform, application of Laplace transform to the solution of Volterra integral equations with convolution type kernels, solution of integro-differential equations using Laplace transform. Fourier Transform, Fourier sine and cosine transforms.	15
IV	**[Course Outcome (s) No. : 4]** Extrema of functionals: Euler's equation, sufficient conditions for the extremum of a functional, extension of the variational methods, Brachistochrone problem, geodesics.	15

***Suggested Readings*:**

1. Wazwaz, A. M. *A First Course in Integral Equations*. 2nd edition World Scientific Publishing Co. 2015.
2. Kanwal, R. P. *Linear Integral Equation. Theory and Techniques*. Academic Press, 2014.
3. Gelfand, I. M. and Fomin, S. V. *Calculus of Variations*. Courier Corporation, 2012.
4. Hildebrand, F. B. *Method of Applied Mathematics*, Courier Corporation, 2012.
5. Raisinghania M. D. *Integral Equation & Boundary Value Problem.* S. Chand Publishing, 2007.
6. Jerri, A. *Introduction to Integral Equations with Applications*, John Wiley & Sons, 1999.

<table>
<tr><td>Course No: 23</td><td colspan="3">Course Name: Functional Analysis</td><td colspan="4">Course Code:
SBSMAT 01 03 02 C 3104</td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td colspan="3"></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">To familiarize with the basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Verify the requirements of a norm, completeness with respect to a norm, relation between compactness and dimension of a space, check boundedness of a linear operator and relate to continuity, convergence of operators by using a suitable norm, compute the dual spaces.

CO2: Distinguish between Banach spaces and Hilbert spaces, decompose a Hilbert space in terms of orthogonal complements.</td></tr>
</table>

	CO3: Check totality of orthonormal sets and sequences, represent a bounded linear functional in terms of inner product, classify operators into self-adjoint, unitary and normal operators. **CO4:** Extend a linear functional under suitable conditions, compute adjoint of operators, check reflexivity of a space, ability to apply uniform boundedness theorem, open mapping theorem and closed graph theorem, check the convergence of operators and functional and weak and strong convergence of sequences.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1,2]** Metric Space, sequences, Cauchy sequences, complete metric spaces and examples, Baire's theorem. Cantor intersection theorem and Banach fixed point principle, normed linear spaces. Banach spaces, examples of Banach spaces and subspaces.	15
II	**[Course Outcome (s) No. : 2]** Continuity of linear maps, Equivalent norms, normed spaces of bounded linear maps, bounded linear functionals, dual spaces of l^p, $\mathbb{R}^n$and reflexivity, Hilbert spaces and examples, orthogonality, orthonormal sets, Bessel's	15

	inequality, Parsevals's theorem,the conjugate space of a Hilbert space.	
III	**[Course Outcome (s) No. :3]** Representation of bounded functional on Hilbert space, adjoint operators, self-adjoint operators, normal and unitary operators, weak and strong convergence, completely continuous operators.	15
IV	**[Course Outcome (s) No. :4]** Hahn-Banach theorem and its applications, uniform boundedness principle, open mapping theorem, projections on Banach spaces, closed graph theorem.	15

***Suggested Readings*:**

1. Simmons, G. F. *Introduction to Topology and Modern Analysis*. McGraw-Hill Pvt. Ltd. 2016.
2. Bachman, G. and Narici, L. *Functional Analysis*. Courier Corporation, 2012.
3. Conway, J. B. *A Course in Functional Analysis*. Springer, 2010.
4. Kreyszig, E. *Introductory Functional Analysis with Applications*. John Wiley, 2007.
5. Royden, H. L. *Real Analysis*. MacMillan Publishing Co., Inc., New York, 4th edition, 1993.

<table>
<tr><td>Course No: 24</td><td colspan="3">Course Name: Mathematical Statistics</td><td colspan="4">Course Code:
SBSMAT 01 03 03 C 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="6">The aim of the course is to enable the students with understanding of various types of measures, various types of probability distributions and testing of hypothesis problems. It aims to equip the students with standard concepts of statistical techniques and their utilization.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="6">After completing this course, student is expected to learn the following:

CO1: Explore the basic ideas about measures of central tendency, dispersion, skewness and kurtosis with their applications and basic idea about probability theory.

CO2: Demonstrate the understanding of random variable, expectation, variance and some discrete distributions.

CO3: Explain the different types of continuous distributions and their utilization.

CO4: Deal with formulation of hypotheses as per situations and their testing.</td></tr>
<tr><td colspan="7">COURSE SYLLABUS</td></tr>
</table>

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Measures of central tendency and dispersion, moments, measures of skewness and kurtosis, correlation and regression. axiomatic approach to the theory of probability, sample space, additive and multiplicative law of probability, conditional probability. Definition and properties of random variables, discrete and continuous random variables, probability mass and density functions, distribution function. Concepts of bivariate random variables.	15
II	**[Course Outcome (s) No.:2]** Mathematical expectation: Definition and its properties. variance, covariance, moment generating function- definitions and their properties. Discrete distributions: Binomial, Poisson and geometric distributions with their properties.	15
III	**[Course Outcome (s) No.: 3]** Continuous distributions: uniform, exponential, gamma and normal distributions with their properties, Central Limit Theorem (Only statement).	15

IV	**[Course Outcome (s) No.: 4]** Statistical estimation, Testing of hypothesis: Null and alternative hypotheses, simple and composite hypotheses, two types of errors, t, F and Chi-Square as sampling distribution and applications.	15

***Suggested Readings*:**

1. Meyer, P. L. Introductory Probability and Statistical Applications. 2nd edition, Addison-Wesley Publishing Company, 2017.
2. Gupta, S. C. and Kapoor, V. K. *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons, 2014.
3. Mood, A. M., Graybill, F. A. and Boes, D. C. *Introduction to the Theory of Statistics*, Tata McGraw Hill, 2014.
4. Spiegel, M. R., Schiller, J. J. and Srinivasan, R. A. *Probability and Statistics*. Tata McGraw-Hill, 2014.
5. Baisnab, A. P. and Jas, M. *Element of Probability and Statistics*, Tata McGraw Hill, 1993.

<table>
<tr><td>Course No: 26</td><td colspan="3">Course Name: Applied Discrete Mathematics</td><td colspan="4">Course Code:
SBSMAT 01 03 01 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The main objective of the course is to introduce concepts of mathematical logic, Lattice and graph theory and to give a brief introduction of Boolean algebra, bipartite graphs and trees and studying for their applications in real life.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Analyze logical propositions using truth tables.

CO2: Understand the concept of lattice.

CO3: Learn about the applications of Boolean algebra in switching theory.

CO4: Use the concept of planar graphs, trees and study for their properties.</td></tr>
</table>

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Formal Logic: Statements, proposition, symbolic representation and tautologies, quantifiers, proposition logic.	15
II	**[Course Outcome (s) No. : 2]** Lattices: Lattices as partially ordered sets, their properties, lattices as algebraic systems, some special lattices, e.g., complete, complemented and distributive lattices, some special lattices e.g., bounded, complemented & distributive lattices.	15
III	**[Course Outcome (s) No. : 3]** Boolean Algebra: Boolean algebra as lattices, various Boolean identities, the switching algebra example, join - irreducible elements, atoms and minterms, Boolean Forms and their equivalence, minterm Boolean forms, sum of products canonical forms, minimization of Boolean functions, applications of Boolean algebra to switching theory (using AND, OR and NOT gates).	15

IV	**[Course Outcome (s) No. : 4]** Graph Theory: Definition of graphs, paths, circuits, cycles and subgraphs, induced subgraphs, degree of a vertex, connectivity, planar graphs and their properties, Euler's formula for connected planar graph, complete and complete bipartite graphs. Trees.	15

***Suggested Readings*:**

1. Tremblay, J.P. and Manohar, R. *Discrete Mathematical Structures with Applications to Computer Science*. Ist edition McGraw Hill Book Co., 2017.
2. Lepschutz, S. and Lipson, M. *Linear Algebra*. 5th edition, Tata McGraw Hill 2012.
3. Ram, B. *Discrete Mathematics*. Pearson Education, 2012.
4. Kenneth H. R. *Discrete Mathematics and Its Applications*, 7th edition, Tata McGraw Hill, 2011.
5. Liu, C. L. *Elements of Discrete Mathematics*. Tata McGraw Hill, 2000.

<table>
<tr><td>Course No: 27</td><td colspan="3">Course Name: Theory of Elasticity</td><td colspan="4">Course Code:
SBSMAT 01 03 02 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course aims to familiarize the students with tensors and the principles and basic equations of elasticity. The course will expose the students to two dimensional problems in Cartesian and polar coordinates.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Use the indicial notation and knowledge of tensor

CO2: Analyse strain, stress and deformation

CO3: Understand the basic principles and field equations of linear elastic solids

CO4: Formulate the solution strategies of various two dimensional problems

CO5: Analyse the propagation of surface waves</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2]** Cartesian tensor: Coordinate transformation, Cartesian tensor of different order, sum or difference and product of two tensors. contraction theorem, quotient law, symmetric & skew symmetric tensors, Kronecker tensor, alternate tensor and relation between them, scalar invariant of second order tensor, eigen values & vectors of a symmetric second order tensor, gradient, divergence & curl of a tensor field. Analysis of strain: affine transformations, infinitesimal affine transformation, geometrical interpretation of the components of strain.	15
II	**[Course Outcome (s) No. : 2]** Strain quadric of Cauchy, principal strains and invariants, general infinitesimal deformation. Saint- Venant's equations of compatibility. Analysis of stress: stress tensor, equations of equilibrium, transformation of co-ordinates, stress quadric of Cauchy, principal stress and invariants, maximum normal and shear stresses.	15

III	**[Course Outcome (s) No. : 3]** Equations of elasticity: Generalized Hooke's law, homogeneous isotropic media, elastic moduli for isotropic media, equilibrium and dynamic equations for an isotropic elastic solid, strain energy function and its connection with Hooke's law, Beltrami-Michell compatibility equations.	15
IV	**[Course Outcome (s) No. : 4, 5]** Two-dimensional problems: Plane strain, plane stress, generalized plane stress, Airy's stress function, general solution of bi-harmonic equation, stresses and displacements in terms of complex potentials, propagation of waves in an isotropic elastic solid medium, waves of dilation and distortion, elastic surface waves such as Rayleigh and Love waves.	15

***Suggested Readings*:**

1. Sadd, M. H. *Elasticity*: *Theory, Applications and Numerics*. Academic Press, 2014.
2. Love, A. E. H. *A Treatise on Mathematical Theory of Elasticity*. Cambridge [Eng.] University Press, 2013.
3. Timoshenko, S. P. and Goodier, J. N. *Theory of Elasticity.* New York McGraw-Hill, 2010.
4. Narayan, S. *Text Book of Cartesian Tensors*. S. Chand & Co., 1968.
5. Sokolnikoff, I. S. *Mathematical Theory of Elasticity*. McGraw-Hill Inc, 2nd edition, 1956.

Course No: 28	**Course Name:** Algebra –II				**Course Code:** SBSMAT 01 03 03 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	III					**4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Nil					
Course Objective	The main objective of this course is to encourage students to develop a working knowledge of the central ideas of Linear Algebra like linear transformations, Vector space, Modules, canonical forms and Field Theory like field extensions, splitting field and Galois theory.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Write abstract mathematical proofs in a clear and logical manner **CO2:** Apply theorems to solve problems in number theory and theory of polynomials over a field **CO3:** Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematical disciplines **CO4:** Think critically by recognizing patterns and principles of algebra and relating them						

	to the number system

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Field, structure of finite fields, finite, algebraic, and transcendental extensions, splitting fields, simple and normal extensions, perfect fields, primitive elements, algebraically closed fields.	15
II	**[Course Outcome (s) No. : 2]** Automorphisms of extensions. Galois extensions, fundamental theorem of Galois theory, solution of polynomials by radicals, Galois group over the rationals.	15

III	**[Course Outcome (s) No. : 3]** Vector spaces, modules, direct products and direct sums, quotients and monomorphisms of modules, modules over PIDs and applications, various canonical forms.	15
IV	**[Course Outcome (s) No. : 4]** Simple and semisimple modules, semisimple rings, Wedderburn-Artin structure theory.	15

***Suggested Readings*:**

1. Lang, S. *Algebra*. Springer, 2012.
2. Herstein, I. N. *Topics in Algebra*. Wiley Eastern Ltd., New Delhi, 2006.
3. Dummit, D.S. and Foote, R.M.*Abstract Algebra (3rd revised edition)*. Wiley, 2003.
4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra, 2nd edition*. Cambridge University Press, 1997.
5. Anderson, F. W. and Fuller, K. R. *Rings and Categories of Modules*. Springer-Verlag New York, 1992.
6. Cohn, P. M. *Algebra*. John Wiley & Sons, Vols. I: 1982, Vols. II: 1989, Vols. III: 1991.

<table>
<tr><td>Course No: 29</td><td colspan="3">Course Name: Fluid Dynamics</td><td colspan="4">Course Code:
SBSMAT 01 03 04 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objective of this course is to provide a treatment of topics in fluid dynamics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems. The objective is to provide the student with knowledge of the fundamentals of fluid dynamics and an appreciation of their application to real world problems.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the basic principles of fluid dynamics, such as Lagrangian and Eulerian approach etc.

CO2: Use the concept of stress in fluids with applications.

CO3: Analyse Irrotational and rotational flows in fluids and some of their properties

CO4: Find analytical solution of Navier Stoke equation and solutions of some benchmark</td></tr>
</table>

	problems.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Concept of fluids, physical properties of fluids, continuum hypothesis, density, specific weight, specific volume, kinematics of fluids, Eulerian and Lagrangian methods of description of flows, equivalence of Eulerian and Lagrangian method, general motion of fluid element, integrability and compatibility conditions, strain rate tensor, streamline, path line, streak lines, stream function, vortex lines, circulation.	15
II	**[Course Outcome (s) No.: 2]** Stresses in Fluids: stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor conservation laws: equation of conservation of	15

	mass (continuity equation), equation of conservation of momentum, Navier Stokes equation, Euler's equation of motion, equation of moments of momentum, equation of energy.	
III	**[Course Outcome (s) No.: 3]** Irrotational and rotational flows: Bernoulli's equation, Bernoulli's equation for irrotational flows, two dimensional irrotational incompressible flows, circle theorem, sources and sinks, sources sink and doublets in two dimensional flows, methods of images.	15
IV	**[Course Outcome (s) No.: 4]** Approximate (analytical) solutions of Navier Stoke equation, order of magnitude analysis, use of similarity variables in analytical solution techniques, solutions of some benchmark problems like; Couette flow, axi-symmetric flows, creeping flows.	15

***Suggested Readings*:**

1. Besaint, W.H. and Ramsey, A.S. *A Treatise on Hydromechanics Part Ihydrostatics*, Andesite Press, 2017.
2. Kundu, P.K., Cohen, I. M. and Dowling, R. D. *Fluid Mechanics*, 6th edition, Academic Press, 2015.
3. O'Neil, M. E., and Chorlton, F. *Ideal and Incompressible Fluid Dynamics*. Ellis Horwood Ltd, 1986.
4. Yuan, S.W. *Foundations of Fluid Mechanics*. Prentice Hall of India Private Limited, New Delhi, 1976.
5. Curle, N. and Davies, H. J. *Modern Fluid Dynamics*.Vol1, D Van Nostrand Company Ltd, London, 1968.

<table>
<tr><td>Course No: 30</td><td colspan="3">Course Name: Fuzzy Set Theory</td><td colspan="4">Course Code:
SBSMAT 01 03 05 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

III</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course aims to introduce students to fundamental concepts in fuzzy sets, fuzzy relations, arithmetic operations on fuzzy sets, probability theory, fuzzy logic and its applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Construct appropriate fuzzy numbers corresponding to uncertain and inconsistent collected data.

CO2: Understand the basic concepts of t- norms, t- conforms and operation of - cut interval.

CO3: Use the concepts of approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, crisp function and its applications.

CO4: Analyse the Integration and differentiation of fuzzy function product set, and

understand the basic concepts of composition of fuzzy relation, fuzzy graph, projection and</td></tr>
</table>

	cylindrical extension

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Concepts of fuzzy set, standard operations of fuzzy set, fuzzy complement, fuzzy union, fuzzy intersection, other operations in fuzzy set, t- norms and t-conorms. Interval, fuzzy number, operation of interval, operation of - cut interval, examples of fuzzy number operation.	15
II	**[Course Outcome (s) No. : 2]** Definition of triangular fuzzy number, operation of triangular fuzzy number, operation of general fuzzy numbers, approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, function with fuzzy constraint, propagation of fuzziness by crisp function, fuzzifying function of crisp variable, maximizing and minimizing set,	15

	maximum value of crisp function.	
III	**[Course Outcome (s) No. : 3]** Integration and differentiation of fuzzy function product set, definition of relation, characteristics of relation, representation methods of relations, operations on relations, path and connectivity in graph, fundamental properties, equivalence relation, compatibility relation, pre-order relation, order relation, definition and examples of fuzzy relation, fuzzy matrix, operations on fuzzy relation.	15
IV	**[Course Outcome (s) No. : 4]** Composition of fuzzy relation, - cut of fuzzy relation, projection and cylindrical extension, extension by relation, extension principle, extension by fuzzy relation, fuzzy distance between fuzzy sets, graph and fuzzy graph, fuzzy graph and fuzzy relation, - cut of fuzzy graph.	15

***Suggested Readings*:**

1. Mohan, C. *An Introduction to Fuzzy Set Theory and Fuzzy Logic*. Anshan Publishers, 2015.
2. Lee, K. H. *First Course on Fuzzy Theory and Applications*. Springer International Edition, 2005.
3. Yen, J., Langari, R. *Fuzzy Logic - Intelligence, Control and Information*. Pearson Education, 1999.
4. Zimmerman, H.J. *Fuzzy Set Theory and its Applications*. Allied Publishers Ltd., New Delhi, 1991.

SEMESTER – IV

<table>
<tr><td>Course No: 32</td><td colspan="3">Course Name: Differential Geometry</td><td colspan="3">Course Code:
SBSMAT 01 04 01 DCEC 3104</td><td></td></tr>
<tr><td>Batch:

2021-2023</td><td>Programme:

M.Sc.
Mathematics</td><td>Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td></td><td></td><td></td><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developables and geodesics.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:
CO1: Learn about the concepts of curvature, torsion, involutes and evolutes.
CO2: Familiarize with several concepts of tangent plane, Helicoids, metric and direction coefficients.
CO3: Understand the concepts of developable surfaces.</td></tr>
</table>

	CO4: Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Curves with torsion: tangent, principal normal, curvature, binormal, torsion, Serret-Frenet formulae, locus of centre of spherical curvature, helix, involutes and evolutes.	15
II	**[Course Outcome (s) No. : 2]** Envelopes: surfaces, tangent plane, envelope, characteristics, edge of regression, developable surfaces, osculating, polar and rectifying developable.	15
III	**[Course Outcome (s) No. : 3]** Curvilinear co-ordinates: first order magnitude, directions on a surface, second order magnitudes, derivative of unit normal, principal directions and curvatures.	15

IV	**[Course Outcome (s) No. : 4]** Geodesics: geodesic property, equations of geodesics, torsion of a geodesic. Bonnet's theorem, Joachimsthal's theorems, geodesic parallels, geodesic ellipses and hyperbolas, Liouville surfaces.	15

***Suggested Readings*:**

1. Weatherburn, C. E. *Differential Geometry of Three Dimensions*, Cambridge University Press, 2016.
2. Graustein, W. C. *Differential Geometry*. Courier Corporation, 2012.
3. Wilmore T. J. *An Introduction to Differential Geometry*, Dover Publications Inc., 2012.
4. Pressley, A. *Elementary Differential Geometry*. Springer, 2002.

<table>
<tr><td>Course No: 33</td><td colspan="5">Course Name: Mathematical Modelling</td><td colspan="2">Course Code:
SBSMAT 01 04 02 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The objectives of this course are to:
Enable students understand how mathematical models are formulated, solved and interpreted.
Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
Equip students with the basic mathematical modelling skills.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand what a mathematical model is and explain the series of steps involved in a mathematical modeling process.

CO2: Use applications of mathematical modeling through difference equations.</td></tr>
</table>

	CO3: Understand and apply the concept of mathematical modeling through difference equations in population dynamics, genetics and probability theory. **CO4:** Apply the concept of mathematical modeling through graph theory.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No.: 1]** Simple situations requiring mathematical modelling, techniques of mathematical modelling, classifications, characteristics and limitations of mathematical models, some simple illustrations, mathematical modelling in population dynamics, mathematical modelling of epidemics through systems of ordinary differential equations of first order mathematical models in medicine, battles and international trade in terms of systems of ordinary differential equations.	15
II	**[Course Outcome (s) No.: 2]** The need for mathematical modelling through difference equations, linear growth and decay models, non-linear growth and decay models, basic theory of linear difference equations with constant coefficients, mathematical modelling through difference equations in economics and finance.	15

III	**[Course Outcome (s) No.: 3]** Mathematical modelling through difference equations in population dynamics and genetics, mathematical modelling through difference equations in probability theory, miscellaneous examples of mathematical modelling through difference equations.	15
IV	**[Course Outcome (s) No.: 4]** Situations that can be modelled through graphs, mathematical models in terms of directed graphs mathematical models in terms of signed graphs, mathematical models in terms of weighted graphs.	15

***Suggested Readings*:**

1. Kapur J. N. *Mathematical Modelling*, 2nd edition, New Age International, 2015.
2. Meerschaert, M. M. *Mathematical Modelling.* Academic Press, 2013.
3. Rutherford, A. *Mathematical Modelling Techniques.* Courier Corporation, 2012.
4. Clive,L. D. *Principles of Mathematical Modelling*. Elsevier, 2004.
5. Bender, E. A. *An Introduction to Mathematical Modelling.* Courier Corporation, 2000.

Course No: 34	**Course Name:** Advanced Numerical Analysis				**Course Code:** SBSMAT 01 04 03 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	IV					**4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Numerical Analysis					
Course Objective	After familiarizing the students with basic numerical techniques in numerical analysis course, this course aims to give exposure to some advanced numerical methods. The course objective is to acquaint the students with a wide range of advanced numerical methods to solve systems of algebraic and transcendental equations, linear system of equations, difference equations, eigenvalue problems, and mainly some finite difference methods for solutions of partial differential equations.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems **CO2:** Solve bivariate interpolation problems, difference equations and eigen value problems.						

	CO3: Understand finite difference methods for numerical solutions of partial differential equations especially heat, wave, Laplace and Poisson equations. **CO4:** Familiarize the students with advantages and limitations of numerical techniques

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2, 4]** General iterative method for the system: $x = g(x)$ and its sufficient condition for convergence. Chebyshev method, Newton-Raphson method. Successive over relaxation (SOR) method for system of linear equations. Bivariate interpolation, B-Spline interpolation and Bezier curves.	15
II	**[Course Outcome (s) No. : 2, 4]** Review of finite difference operators, difference equations, order of difference equation, degree of difference equation, solution of difference equations, use of generating function in the solution of difference equation. Jacobi, Givens and Householder methods real symmetric matrix	15

III	**[Course Outcome (s) No. : 3, 4]** Numerical solutions of parabolic equations of second order in one space variable –two and three levels explicit and implicit difference schemes, truncation errors and stability. Numerical solution of parabolic equations of second order in two space variable-improved explicit schemes, implicit methods, alternating direction implicit (ADI) methods.	14
IV	**[Course Outcome (s) No. : 3, 4]** Numerical solution of hyperbolic equations of second order in one and two space variables with constant and variable coefficients-explicit and implicit methods. ADI methods. Numerical solutions of elliptic equations-approximations of Laplace and biharmonic operators, solutions of Dirichlet, Neumann and mixed type problems with Laplace and Poisson equations in rectangular, circular and triangular regions. ADI methods.	16

***Suggested Readings*:**

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge University Press, 2019.
2. Gupta. R. S., *Elements of Numerical Analysis*, 2nd Edition, Cambridge University Press, 2015.
3. Atkinson, K. and Han, W. *Theoretical Numerical Analysis*, Springer Science & Business Media, 2010.
4. Bradie, B. *A friendly introduction to Numerical Analysis.* Pearson Education, 2007.
5. Bazaraa, M.S., Sherali, H.D. and Shetty, C.M. *Nonlinear Programming Theory and Algorithms.* John Wiley and Sons, 2004.
6. Smith, G. D. *Numerical solution of Partial Differential Equations: Finite Difference Methods*.3rd edition. Oxford University Press, 1985.

Course No: 35	**Course Name:** Finite Element Methods				**Course Code:** SBSMAT 01 04 04 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	IV					**4**
			3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 hours **Pre-requisite of course:** Nil

Course Objective	The course aims to provide the fundamental concepts of the element method mainly including shape functions and general linear and higher order elements up to 3 dimensions. The course objective is to acquaint the students about application of finite element methods for solving various boundary value problems.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the general theory of Finite Element method and its difference with finite difference method **CO2:** Use the role and significance of shape functions in finite element formulations and use of linear, quadratic, and cubic shape functions for interpolation **CO3:** Formulate some important 1, 2 and 3 dimensional elements

	CO4: Apply the weighted residual and variational approaches in solving some boundary value problems

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2]** General theory of finite element methods, difference between finite element and finite difference methods, review of some integral formulae, concept of discretization, different coordinates, one dimensional finite elements, concept of shape functions, stiffness matrix, connectivity, boundary conditions, and equilibrium equation.	15
II	**[Course Outcome (s) No. : 2, 3]** Numerical integration, construction of shape functions: linear elements (one dimensional bar element, two dimensional-triangular and rectangular elements, three dimensional tetrahedron element).	15
III	**[Course Outcome (s) No. : 2, 3]** Higher order elements: one dimensional quadratic element, two dimensional triangular element, rectangular element, three dimensional tetrahedron element: quadratic element and higher order elements	14

IV	**[Course Outcome (s) No. : 4]** Weighted residual and variational approaches (Galerkin method, collocation method, Rayleigh Ritz method etc.), solving one-dimensional problems. Application of finite element methods for solving various boundary value problems, computer procedures for finite element analysis	16

***Suggested Readings*:**

1. Rao, S. S. *The Finite Element Method in Engineering*. 5th edition, Butterworth-Heinemann, 2017.
2. Hughes, T. J. R. *The Finite Element Method (Linear Static and Dynamic Finite Element Analysis)*. Courier Corporation, 2007.
3. Zienkiewicz, O. C. and Taylor, R. L. *The Finite Element Method: The Basis*. Butterworth-Heinemann, 2000.
4. Smith, G. D. *Numerical solution of Partial Differential Equations: Finite difference methods*. Oxford Applied Mathematics and Computing Science Series, 1985.

<table>
<tr><td>Course No: 36</td><td colspan="3">Course Name: Advanced Complex Analysis</td><td colspan="4">Course Code:
SBSMAT 01 04 05 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc. Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours</td></tr>
<tr><td colspan="5">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The primary objective of this course is to understand the notion of logarithmically convex function and its fusion with maximum modulus theorem, the spaces of continuous, analytic and meromorphic functions, Runge's theorem and topics related with it, introduce harmonic function theory leading to Dirichlet's problem, theory of range of an entire function leading to Picard and related theorems.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.

CO2: Be familiar with metric on spaces of analytic, meromorphic and analytic functions, equi-continuity and normal families leading to Arzela-Ascoli and related theorems.

CO3: Appreciate the richness of simply connected region which connects various fields</td></tr>
</table>

	topology, analysis and algebra. **CO4:** Know how big the range of an entire function is as well as Picard and related theorems.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Maximum modulus principle, Schwarz's lemma, convex functions and Hadamard's three circles theorem, Phragmen-Lindelof theorem.	15
II	**[Course Outcome (s) No. : 2]** The space of continuous functions, spaces of analytic functions, The Riemann mapping theorem, Weierstrass factorization theorem. Gamma function, Reimann zeta function.	15
III	**[Course Outcome (s) No. : 3]** Analytic continuation, Runge's theorem, simple connectedness, Mittag-Leffier's theorem, Schwarz reflection principle, analytic continuation.	15

IV	**[Course Outcome (s) No. : 4]** Basic properties of harmonic functions, harmonic functions on a disk, Jensen's formula, Bloch's theorem, The Little Picard theorem, Schottky's theorem, The Great Picard theorem.	15

***Suggested Readings*:**

1. Ahlfors, L.V. Complex Analysis. 3rd edition, McGraw-Hill, 2017.
2. Alpay, D. *A Complex Analysis Problem Book.* Birkhäuser, 2016.
3. Churchill, R. V. and Brown, J. W. *Complex Variables and Applications. 9th edition*, McGraw Hill Education, 2014.
4. Edward,S. B. and Snider, Arthur D. *Fundamental of Complex Analysis with Applications to Engineering and Sciences*. Pearson Education, 2014.
5. Lang, S. *Complex Variable.* Springer, 2013.
6. Conway J. B. *Functions of One Complex Variable*. Springer, 2000.

<table>
<tr><td>Course No: 37</td><td colspan="3">Course Name: Introduction to Cryptography</td><td colspan="4">Course Code:
SBSMAT 01 04 06 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="6">The purpose of the course is to give a simple account of cryptography. Upon completion of the course, students will have a working knowledge of the fundamental definitions and theorems of elementary congruences, solve congruence equations and systems of equations with one and more variables. They will understand the language, notation of Caesar Cipher and explored to cryptography. We will also discussion on Diffie-Hellman RSA public key cryptosystem.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="6">After completing this course, student is expected to learn the following:

CO1: Understand the operations with congruence’s, linear and non-linear congruence equations.

CO2: Use the basics of RSA security and be able to break the simplest instances and analyze</td></tr>
</table>

	the basic concepts of remote coin flipping, elliptic curve based cryptography. **CO3:** Apply the theorems: Fermat's last theorem, prime number theorem and zeta function. **CO4:** Understand and use the numbers: Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Modular arithmetic, congruence, primitive roots, cryptography introduction, Caesar Cipher, Diffie-Hellman RSA public key cryptosystem, Knapsack cryptosystem, application of primitive roots to cryptography.	15
II	**[Course Outcome (s) No. : 2]** Applications of cryptography in primality testing and factorization of large composite numbers, remote coin flipping. Elliptic curve based cryptography.	15

III	**[Course Outcome (s) No. : 3]** Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers, representation of integers as sum of Squares.	15
IV	**[Course Outcome (s) No. : 4]** Linear and non-linear Diophantine equations, Fermat's last theorem, prime number theorem and zeta function.	15

***Suggested Readings*:**

1. Tilborg, H. C. A. *Fundamentals of Cryptology.* Springer, 2013.
2. Buchmann, J. A. *Introduction to Cryptology*.Springer Science & Business Media, 2012
3. Burton , D. M. *Elementary Number Theory*, Tata McGraw Hill Publishing House, 2006.
4. Menezes, A. J., V.,Oorschot, P. C. and Vanstone,S. A. *Handbook of Applied Cryptography*. CRC Press, 1996.
5. Koblitz, N. *A Course in Number Theory and Cryptography. 2nd edition* Springer, 1994**.**
6. Simmons, G. J. *Contemporary Cryptology*, *The Science of Information Integrity.*New York, IEEE Press, 1992

Course No: 38	**Course Name:** Advanced Abstract Algebra						**Course Code:** SBSMAT 01 04 07 DCEC 3104
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Mathematics	IV	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks			**Examination Duration:** 3 hours **Pre-requisite of course:** Nil				
Course Objective	The main objective of this course is to encourage students to develop a working knowledge of the central ideas of modules like cyclic modules, simple, semi-simple modules uniform modules, primary modules and theory of Noetherian and Artinian modules.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Explain the fundamental concepts of modules and their role in modern mathematics and applied contexts. **CO2:** Demonstrate accurate and efficient use of finitely generated Abelian groups. **CO3:** Apply the theorems: fundamental structure theorem of finitely generated modules over principal ideal domain, Noether- Lasker theorem, Hilbert basis theorem and Wedderburn - Artin theorem, Maschk's theorem.						

	CO4: Solve the problem using Nilradical and Jacobson radicals, operations on ideals, extension and contractions applied to diverse situations in physics, engineering and other mathematical contexts.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Cyclic modules, simple and semi-simple modules, Schur's lemma, free modules, fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated Abelian groups.	15
II	**[Course Outcome (s) No. : 2]** Uniform modules, primary modules and Noether- Lasker theorem, Noetherian and Artinian modules and rings with simple properties and examples.	15
III	**[Course Outcome (s) No. : 3]** Nilpotent ideals in Noetherian and Artinian rings, Hilbert basis theorem, Nakayama's lemma, Nilradical and Jacobson radicals, operations on ideals, extension and contraction.	15

IV	**[Course Outcome (s) No. : 4]** Hom(R,R), opposite rings, Wedderburn -Artin theorem, Maschk's theorem, equivalent statement for left Artinian rings having non-zero nilpotent ideals.	15

***Suggested Readings*:**

1. Rotman, J. J.*Advanced Modern Algebra*. *3rd edition*. American Mathematical Soc., 2015.
2. Atiyah, M. F. and Macdonald, I. G. *Introduction to Commutative Rings*. Sarat Book House, 2007.
3. Curtis, C. W. and Reiner, I. *Representation Theory of finite Groups and Associative Algebras*. American Mathematical Society, 2006.
4. Lam, T. Y. *Lectures on Modules and Rings*. GTM Vol. 189, Springer-Verlag, 1999.
5. Bhattacharya,P. B., Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra*. 2nd edition, Cambridge University Press, Indian edition, 1997.
6. Anderson, F. W. and Fuller, K. R. *Rings and Categories of Modules.* Springer-Verlag New York, 1992.
7. Cohn, P. M. *Algebra, Vols. I, II & III*, John Wiley & Sons, (Vol. I-1982, Vol. II- 1989, Vol-III-1991.

.

Course No: 39	Course Name: Measure theory and Integration				Course Code: SBSMAT 01 04 08 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	IV					**4**
			3	1	0	4	**Total Hours: 60**

Total Evaluation Marks: 100	**Examination Duration:** 3 hours
CIE: 30 Marks **TEE:** 70 Marks	**Pre-requisite of course:** Nil

Course Objective	Measure theory provides a foundation for many branches of mathematics such as harmonic analysis, ergodic theory, theory of partial differential equations and probability theory. It is a central, extremely useful part of modern analysis, and many further interesting generalizations of measure theory have been developed.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Use the concepts of measurable set and measurable function **CO2:** State and explain the construction of the Lebesgue integral and use it **CO3:** Apply the theorems of monotone and dominated convergence and Fatou's lemma **CO4:** Describe the construction of product measure and to apply Fubini's theorem

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Length of an open set, concept of measure, Lebesgue outer measure and measurable sets, example of non-measurable set, Sigma algebra, Borel sets, G_δ and F_σ –sets, Outer and inner regularity of Lebesgue measure.	15
II	**[Course Outcome (s) No. : 2]** Set function, abstract measure spaces, properties of measures, some examples of measures, measurable spaces, measurable functions, combinations of measurable functions, and limits of measurable functions.	15
III	**[Course Outcome (s) No. : 3]** Review of Riemann integral, integrable simple functions, the Lebesgue integration of a measurable function, integration with respect to a measure.	15

IV	**[Course Outcome (s) No. : 4]** Almost everywhere convergence, convergence in measure, Fatou's Lemma, monotone and dominated convergence theorems.	15

***Suggested Readings*:**

1. Berberian, S. K. *Measure and Integration*. AMS Chelsea Publications, 2011.
2. Royden, H. L. and Fitzpatrick P. M. *Real Analysis*. 4th edition, Pearson India, 2010.
3. Barra, G. de. *Measure Theory and Integration*. New Age International (P) Ltd., 2009.
4. Rana, I. K. *An Introduction to Measure and Integration.*2nd edition, Narosa Publishing House, 2004.
5. Folland, G. B. *Real Analysis.* John Wiley & Sons, Inc., New York, 1999.
6. Hewitt, E. and Stromberg, K. *Real and Abstract Analysis*. Springer-Verlag, New York, 1975.

Course No: 40	Course Name: Mechanics				Course Code: SBSMAT 01 04 09 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Mathematics	IV					
			3	1	0	4	**Total Hours:60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: Nil					
Course Objective	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.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the notion of moment and product of inertia. **CO2:** Recognize the dynamics involved in projectile motion, pendulum motion, simple harmonic motion and related problems. **CO3:** Use the Lagrangian and Hamiltonian functions to formulate the equation of motion for mechanical systems. **CO4:** Evaluate canonical equations by means of generating functions and eventually						

	develop Hamilton-Jacobi method to solve equations of motion**.**

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Moments and products of inertia, theorems of parallel and perpendicular axes, principal axes, the momental ellipsoid, equimomental systems, coplanar distributions.	15
II	**[Course Outcome (s) No. : 2]** Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations, generalized coordinates, holonomic and non-holonomic systems. scleronomic and rheonomic systems, Lagrange's equations for a holonomic system, Lagrange's equations for a conservative and impulsive forces, kinetic energy	15

	as quadratic function of velocities.	
III	**[Course Outcome (s) No. : 3]** Generalized potential, energy equation for conservative fields, Hamilton's variables. Donkin's theorem. Hamilton canonical equations, cyclic coordinates, Routh's equations. Poisson's bracket. Poisson's identity, Jacobi-Poisson theorem. Hamilton's principle, principle of least action.	15
IV	**[Course Outcome (s) No. : 4]** Poincare Cartan integral invariant. Whittaker's equations. Jacobi's equations. Statement of Lee Hwa Chung's theorem. Hamilton-Jacobi equation. Jacobi theorem. Method of separation of variables. Lagrange brackets, condition of canonical character of a transformation in terms of Lagrange brackets and Poisson brackets, invariance of Lagrange brackets and Poisson brackets under canonical transformations.	15

***Suggested Readings*:**

1. Spiegel, M.R. Theory & Problems of Theoretical Mechanics, Schaum Outline Series McGrawHill, 2017.
2. Rana, N. C. and Joag, P. C. *Classical Mechanics*. McGraw Hill, 2013.
3. Rao,S. K.*Classical Mechanics*. PHI Learning Pvt. Ltd., 2005.
4. Chorlton, F. *Textbook of Dynamics*. CBS Publishers & Dist. Pvt. Ltd., 2004.
5. Louis N. H. and Janet D. F. *Analytical Mechanics*. Cambridge University Press, 1998.
6. Gantmacher, F. *Lectures in Analytical Mechanics*. Mir Publishers, Moscow, 1975.

<table>
<tr><td>Course No: 41</td><td colspan="3">Course Name: Number Theory</td><td colspan="4">Course Code:
SBSMAT 01 04 10 DCEC 3104</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td colspan="3">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The purpose of the course is to give a simple account of classical number theory, prepare students to graduate-level courses in number theory and algebra, and to demonstrate applications of number theory. In this course, students will have a working knowledge of the fundamental definitions and theorems of elementary number theory, be able to work with congruence’s, solve congruence equations and systems of equations with one and more variables, and be literate in the language and notation of number theory.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples and handle linear Diophantine equations

CO2: Use the operations with congruence’s, linear and non-linear congruence equations
CO3: Apply the theorems: Chinese Remainder Theorem, Lagrange theorem, Fermat's</td></tr>
</table>

	theorem, Wilson's theorem **CO4:** Analyse arithmetic functions in areas of mathematics

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Representation of the real numbers by decimals, divisibility, G.C.D and L.C.M., primes, Fermat numbers, congruences and residues, theorems of Euler, Fermat and Wilson, solutions of congruences, linear congruences, Chinese remainder theorem.	15
II	**[Course Outcome (s) No. : 2]** Arithmetical functions $\varphi(n)$, $\mu(n)$ and $d(n)$ and $\sigma(n)$, Mobius inversion formula, congruences of higher degree, congruences of prime power modulli and prime modulus, power residue.	15

III	**[Course Outcome (s) No. : 3]** Quadratic residue, Legendre symbols, lemma of Gauss and reciprocity law. Jacobi symbols, irrational numbers, irrationality of e and π. Finite continued fractions, simple continued fractions, infinite simple continued fractions.	15
IV	**[Course Outcome (s) No. : 4]** Periodic continued fractions, approximation of irrational numbers by convergent, best possible approximation, Farey series, rational approximation, Pell's equations, Hurwitz theorem, Lagrange four square theorem.	15

***Suggested Readings*:**

1. Apostol, T. M. *Introduction to Analytic Number Theory*. Springer 2014.
2. Niven, I. and Zuckerman, H. S. *Introduction to the Theory of Numbers*. John Wiley & Sons, 2008.
3. Burton, D. M. *Elementary Number Theory*. Tata McGraw Hill Publishing House, 2006.
4. Hardy, G. H. and Wright, E. M. *Theory of Numbers*. Oxford Science Publications, 2003.
5. Davenport, H. *Higher Arithmetic*. Cambridge University Press, 1999.

.

Course No: 42	**Course Name:** Mathematics for Finance and Insurance				**Course Code:** SBSMAT 01 04 11 DCEC 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	IV					**4**
			3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** Nil					
Course Objective	This course introduces the basic concepts of Financial Management such as Insurance and Measurement of returns under uncertainty situations. The philosophy of this course is that Time value of Money - Interest rate and discount rate play a fundamental role in Life Insurance Mathematics – Construction of Morality Tables.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Demonstrate knowledge of the terminology related to nature, scope, goals, risks and decisions of financial management. **CO2:** Predict various types of returns and risks in investments and take necessary protective measures for minimizing the risk. **CO3:** Develop ability to understand, analyze and solve problems in bonds, finance and						

	insurance. **CO4:** Build skills for computation of premium of life insurance and claims for general insurance using probability distributions.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Financial Management –overview. Nature and scope of financial management. Goals and main decisions of financial management. Difference between risk, Speculation and gambling. Time value of Money - Interest rate and discount rate. Present value and future value discrete case as well as continuous compounding case. Annuities and its kinds.	15
II	**[Course Outcome (s) No. : 2]** Meaning of return. Return as Internal Rate of Return (IRR). Numerical methods like Newton Raphson method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk	15

	and uncertainty. Types of risks. Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe Single Index Model-Systematic Risk and Unsystematic Risk.	
III	**[Course Outcome (s) No. : 3]** Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds. Insurance Fundamentals – Insurance defined. Meaning of loss. Chances of loss, Peril, Hazard, proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures- feature of a loss that is ideal for insurance.	15
IV	**[Course Outcome (s) No. : 4]** Life Insurance Mathematics – Construction of Morality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life. Determination of claims for General Insurance – Using Poisson Distribution and Negative Binomial Distribution –the Polya Case. Determination of the amount of Claims of General Insurance – Compound Aggregate claim model and its properties, Claims of reinsurance. Calculation of a compound claim density function F, Recursive and approximate formulae for F.	15

***Suggested Readings*:**

1. Ross, S. M. *An Introduction to Mathematical Finance*. Cambridge University Press, 2019.
2. Elliott, R. J. and Kopp, P. E. *Mathematics of Financial Markets*. Sprigner Verlag, New York Inc, 2018.
3. Damodaran, A. *Corporate Finance - Theory and Practice*. John Wiley & Sons, Inc, 2012.
4. Hull, J. C. *Options, Futures, and Other Derivatives*. Prentice-Hall of India Private Ltd, 2010.
5. Daykin, C. D., Pentikainen, T. and Pesonen, M. *Practical Risk Theory for Actuaries*. Chapman & Hall, 2008.
6. Dorfman, M. S. *Introduction to Risk Management and Insurance*. Prentice Hall, Englwood Cliffs, New Jersey, 1999.
7. Neftci, S. N. *An Introduction to the Mathematics of Financial Derivatives*. Academic Press, Inc, 1991.

<table>
<tr><td>Course No: 43</td><td colspan="5">Course Name: Programming in MATLAB</td><td colspan="2">Course Code:
SBSMAT 01 04 01 SEEC 0120</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 3</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>0</td><td>Total Hours: 45</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="5">Examination Duration: 3 hours

Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course objective is to familiarize the students with problem solving through MATLAB. The course aims to give exposure to basic concepts of the MATLAB programming. The course aims to design the MATLAB programs for various numerical methods.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Overview and display format of MATLAB programs

CO2: Acquire knowledge of various elementary built-in functions, data types and Matrix operations

CO3: Learn about control flow and loop structures

CO4: Write MATLAB programs for various numerical methods use to solve nonlinear equations, system of linear equations, interpolation, numerical differentiation and integrations,</td></tr>
</table>

	differential equations.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1, 2]** Overview of MATLAB, operators, display format, elementary built-in functions, working with variables, general commands, data types, data import, arrays, operations with arrays.	18
II	**[Course Outcome (s) No. : 2, 3]** Matrices: eigenvalues and eigenvectors, similarity transformation and diagonalization, functions, script files, operators, loops and conditional statements, programming in MATLAB, graphics- 2-D and 3-D plots, input and output.	20
III	**[Course Outcome (s) No. : 2, 3, 4]** Applications in numerical methods: bisection method, false position (Regula-Falsi) method, Newton–Raphson) method System of linear equations, LU decomposition, Gauss elimination method, Gauss Seidel method, Gauss Jordan method, interpolation, Lagrange and Newton	18

	polynomials.	
IV	**[Course Outcome (s) No. : 3, 4]** Applications to numerical differentiation and integrations: Trapezoidal method and Simpson method, Runge–Kutta method, introduction to working with modules in MATLAB.	19

***Suggested Readings*:**

1. Kumar, S. S. and Lenina, S. V. B. *Matlab: Easy Way of Learning*. PHI Learning Pvt. Ltd., 2016.
2. Pratap, R. *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*. Oxford University Press, 2016.
3. Chapman, S. J. Matlab Programming for Engineers, 5th edition, Cengage Learning, 2015.
4. Otto, S.R. and Denier, J.P. *An Introduction to Programming and Numerical Methods in MATLAB*. Springer-Verlag, 2005.
5. Yang, W. Y., Cao, W., Chung, T. and Morris, J. *Applied Numerical Methods using MATLAB*. John Wiley Interscience, 2005.
6. *Getting Started with MATLAB,* Maths Works Inc. *www. in.mathsworks.com.*

Course No: 44	**Course Name:** Automata Theory				**Course Code:** SBSMAT 01 04 02 SEEC 0120		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week:**
2021-2023	M.Sc. Mathematics	IV					**3**
			0	1	2	0	**Total Hours: 45**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: Nil					

Course Objective	This course introduces the basic concepts of Computability Theory such as Moore and Mealy machines. The main objective of this course is to encourage students to develop a working knowledge of the central ideas of finite state machines, reduced machines, regular Languages, regular expressions and context free grammars.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Apply a number of proof techniques to theorems in language design and develop a clear understanding of decidability and undecidability. **CO2:** Understand the concepts of deterministic and non-deterministic finite state automata and their equivalence**.** **CO3:** Demonstrate the equivalence between context-free grammars and pushdown

	automata. **CO4:** Appreciate the power of the Turing machine, as an abstract automaton, that describes computation, effectively and efficiently.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** Introductory Computability Theory - Finite state machines and their transition table diagrams, equivalence of finite state machines, reduced machines, homomorphism and finite automata acceptors.	12
II	**[Course Outcome (s) No. : 2]** Non-deterministic finite automata and equivalence of its power to that of deterministic finite automata, Moore and Mealy machines.	11
III	**[Course Outcome (s) No. : 3]** Regular Languages, Regular Expressions, Properties and uses of Regular	12

	expressions, Finite automata and Regular Expressions.	
IV	**[Course Outcome (s) No. : 4]** Context free Grammars and Context free Languages, Simplification of Context free Grammar, Pumping Lemma, Kleene's Theorems	10

***Suggested Readings*:**

1. Gersting,J. L. *Mathematical Structures for Computer Science*. 7th edition, Computer Science Press, New York, 2020.
2. Liu, C.L. *Elements of Discrete Mathematics*. McGraw-Hill Book Co. 2019.
3. Nasir S.F.B. and Srimani P. K.*A Textbook on Automata Theory*. Cambridge University Press India Pvt. Ltd., 2018.
4. Ram, B. *Discrete Mathematics*. Vinayak Publishers and Distributors, Delhi, 2010.
5. Lipschutz, S. and Schiller, J. *Finite Mathematics*. McGraw Hill, 1994.
6. Tremblay, J. P. and Manohar, R. *Discrete Mathematical Structures with Applications to Computer Science*. McGraw-Hill Book Co., 1997.

<table>
<tr><td>Course No: 45</td><td colspan="3">Course Name: Artificial Intelligence and Machine Learning</td><td colspan="4">Course Code:
SBSMAT 01 04 03 SEEC 0120</td></tr>
<tr><td rowspan="2">Batch:

2021-2023</td><td rowspan="2">Programme:

M.Sc.
Mathematics</td><td rowspan="2">Semester:

IV</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hrs per Week: 3</td></tr>
<tr><td></td><td>1</td><td>2</td><td>0</td><td>Total Hours: 45</td></tr>
<tr><td colspan="2" rowspan="2">Total Evaluation Marks:
100

CIE: 30 Marks

TEE: 70 Marks</td><td colspan="6">Examination Duration: 3 hours</td></tr>
<tr><td colspan="6">Pre-requisite of course: Nil</td></tr>
<tr><td>Course Objective</td><td colspan="7">Theories and methods for automating and representing knowledge with an emphasis on learning from input/output data. The course covers a wide variety of approaches, including Supervised Learning, Neural Nets and Deep Learning, Reinforcement Learning, Expert Systems, Bayesian Learning, Fuzzy Rules, and Genetic Algorithms. Each student focuses on two of these approaches and creates a term project.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">After completing this course, student is expected to learn the following:

CO1: Understand the concept of Artificial Intelligence.

CO2: Familiarize with Knowledge based AI systems and approaches

CO3: Apply the aspect of Probabilistic approach to AI and Identify the Neural Networks and NLP in designing AI models.</td></tr>
</table>

	CO4: Recognize the concepts of Machine Learning and its deterministic tools.

COURSE SYLLABUS

NOTE:

Eight questions will be set, two from each of the UNIT. The candidates are required to attempt any five questions in all selecting at least one question from each section. All questions carry equal marks. Unit I will be taught via online mode.

OR

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	**[Course Outcome (s) No. : 1]** History of artificial intelligence, The birth of artificial intelligence, AI Winters, Todays' AI, Historical milestones in the development of AI, Great contributors, People who have influenced AI , Differences between strong AI and weak AI, Artificial Intelligence definitions, Emergence of AI – Technological advances.	12
II	**[Course Outcome (s) No. : 2]** Machine Learning ---> Deep Learning --->AI, Functions of AI, Characteristics of artificial intelligence, Applications of AI, AI in health care, Industry 4.0, AI in manufacturing, AI in education sector, AI in business, AI in Finance Sector, AI in Law, AI in society, Cognitive science and AI, Cognition and process of Cognition, Disciplines in Cognitive science, Multidisciplinary subject,	11

	Linguistics, Artificial intelligence as Cognitive science, Methods in Cognitive science, Watson.	
III	**[Course Outcome (s) No. : 3]** Introduction to knowledge representation systems, Knowledge representation using logic, Propositional logic, Semantics of propositional logic, Properties of propositional logic statements, Tautologies and logical implication, Resolution, Conjunctive normal form, Resolution is valid, Resolution algorithm, Knowledgebase systems, Structure of a knowledge based system, Recap of artificial intelligence.	12
IV	**[Course Outcome (s) No. : 4]** Components of expert systems, Expert systems development, Wumpus world, Logic, A simple knowledge base, Exploring the Wumpus world, Semantic net, Inference in semantic networks, Semantic networks: Types and components, Types of relationships in semantic network, Frames, Frames: Some examples, Non-monotonic logic, Circumscription, Default logic, Artificial Neural Network, Natural language processing, Classical NLP, Feed-forward networks, Recurrent neural networks and recursive networks, Features for NLP problems, Framenet Vs. Wordnet, Features for text, Features for word relations, NGRAM features, Some terminologies.	10

***Suggested Readings*:**

1. Gersting, J. L. *Mathematical Structures for Computer Science*. 7th edition, Computer Science Press, New York, 2020.
2. Markiewicz, M. and Zheng, J. *Getting Started with Artificial Intelligence: A Practical Guide to Building Enterprise*. Ist edition, Shroff/O'Reilly, 2019.
3. Theobald, O. *Machine Learning: Make Your Own Recommender System*. Scatterplot Press, 2018.
4. Flasinski, M. *Introduction to Artificial Intelligence*. Springer, 2017.

9. TEACHING-LEARNING PROCESS

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

10. IMPLEMENTATION OF BLENDED LEARNING

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

Key features of Blended Learning

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

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

11. ASSESSMENT AND EVALUATION

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

1. **Examination and Internal Assessment:** The internal assessment work and the End-Semester examination shall have the weightage of 30% and 70%, respectively.
2. **Internal Assessment:**
   (i) Internal Assessment shall be done on a continuous basis, taking into account the student's class performance, completion of assignments and performance at the two compulsory sessional tests to be conducted in a semester. For the sake of uniformity, particularly for interdepartmental transfer of credits, there shall be a uniform procedure of examination to be adopted by all faculty members.
   (ii) Internal Assessment Test 1 shall be held around the sixth week of the semester for the syllabi covered till then.
   (iii) Internal Assessment Test 2 shall be held around the twelfth week for the syllabi covered between seventh and twelfth week.
   (iv) For conducting Internal Assessment, one or more assessment tools, such as written tests, assignments, oral quizzes, paper presentation, laboratory work, etc., suitable to the course may be employed.
   (v) The Internal Assessment for theory shall consist of the following components with marks indicated against each:-
   (a) Attendance 5 marks

Below 75 %	Nil
75% to < 80 %	1 mark
80% to < 85 %	2 marks
85% to < 90%	3 marks
90% to < 95%	4 marks
95% to 100%	5 marks
(b) Assignments/Presentations and Class Participation	5 marks
(c) Internal Assessment Test-1	10 marks
(d) Internal Assessment Test-2	10 marks

This criteria shall be made known to the students at the commencement of each semester. For practical examination, 70 percent of the marks will be awarded through an end semester practical exam and remaining 30 percent of the marks will consist of internal assessment to be awarded by concerned faculty member(s) of the concerned department. Maximum 05 marks to be awarded for attendance of students (Same as mentioned in case of internal assessment for theory examination).

Assessment of Seminar paper: The seminar paper shall be assessed on the basis of the contents of the paper submitted and its presentation, equally. The assessment will be made by the concerned teacher/advisor/supervisor. A Seminar presentation paper will not exceed 4 credits per semester.

(vi) The Head/Incharge of the Department may allow a student to repeat one sessional test, if his/her application in this regard is considered as genuine on valid reasons.

(vii) A student is required to secure a minimum of 'P' grade in the Internal Assessment and in the End-Semester examinations in the aggregate. However, he/she shall have to pass the practical examination separately, with a minimum of 'P' grade.

3. End-Semester Examination:

(i) The End-semester Examinations covering the entire syllabus prescribed for the course and carrying 70% of weightage, shall be conducted by the Examination Branch of the University, in consultation with the Head of the Department.

(ii) The Examiners or Board of Examiners shall be appointed for each course by the Board of Studies of the Department concerned.

(iii) The distribution of weightage for the valuation of semester-long project work/ dissertation shall be:

(a) Periodic presentation : 30%

(b) Project Report : 40%

(c) Viva voce : 30%

Or

as decided by the Board of Studies of the Department concerned.

(iv) The hall ticket/admit card shall be issued to the student on the recommendation of the Head of the Department, subject to the following conditions:

(a) Having fulfilled the requirement of attendance as prescribed, and,

(b) Submission of a "No dues" certificate in the prescribed form.

4. Letter Grades and Grade Points:

An absolute grading system shall be adopted to grade the students.

(i) Under the absolute grading system, marks shall be converted to grades based on pre-determined class intervals.

(ii) In the End-semester theory or practical examinations, the examiner shall award the marks and these marks shall be further converted into Grades/Grade points by the examination branch in accordance with the provisions of the Ordinance.

(iii) Detail Marks Sheet issued at the end of the semester or the programme shall carry marks/percentage and equivalent grades both.

(iv) The University shall adopt the 10-point Grading System, with the Letter Grades as given under:

Letter Grade	**Grade Point (SGPA/CGPA)**	**Range of Grade Point (SGPA/CGPA)**	**Class Interval (in %)**
O (Outstanding)	10	Above 9 to 10	Above 90 and < 100
A+ (Excellent)	9	Above 8 to 9	Above 80 and < 90
A (Very Good)	8	Above 7 to 8	Above 70 and < 80
B+ (Good)	7	Above 6 to 7	Above 60 and < 70
B (Above Average)	6	Above 5 to 6	Above 50 and < 60
C (Average)	5	Above 4.5 to 5	Above 45 and < 50
P (Pass)	4	4 to 4.5	40 to 45
F (Fail)	0		< 40
Ab (Absent)	0		Absent

Note:

(i) F= Fail, and the students graded with 'F' in a programme or course shall be required to re-appear in the examination. However, students appearing in their final Semester Examination, may be permitted to appear in the reappear papers of the preceding odd Semesters.

(ii) The minimum qualifying marks for a course or programme shall be 40% (i.e., 'P' grade).

(iii) The students shall have to qualify at the Internal Assessment and the End-Semester examinations in the aggregate, and in the practical examinations, separately.

(iv) There shall be no rounding off of SGPA/CGPA.

(v) The SGPA/CGPA obtained by a student shall be out of a maximum of 10 points.

(vi) In order to be eligible for the award of the Master's degree of the University, a student must obtain CGPA of 4 at the end of the programme.

(vii) Provided that the student who is otherwise eligible for the award of the degree/diploma but has secured a CGPA of less than 4 at the end of the permissible period of semesters may be allowed by the Department concerned to repeat the same course(s) or other courses of the same type in lieu thereof in the extra semesters provided in Clause 7 on "Duration of Programme".

(viii) The Cumulative Grade Point Average (CGPA) obtained by a student shall be classified into the following division/Class:

CGPA	**Class/ Division**
Above 9	Outstanding
Above 8 to 9	First Class (With Distinction)
6 to 8	First Class
5.5 to < 6	High-Second Class
5 to < 5.5	Second Class

5. Setting of question papers and Evaluation

(i) The question papers for the End-Semester theory examination shall be set and evaluation of answer books shall be done by the examiners (Internal and/or External ordinarily in the ratio of 60:40) out of the Panel of Examiners recommended by the Board of Studies of the Department concerned on the basis of their expertise/ specialization.

In case of unavailability of external examiners, the Vice Chancellor may allow the evaluation to be performed by the internal examiners only so that the declaration of results is not delayed. The question papers shall be moderated by a Board of Moderators

to be appointed by the Controller of Examinations out of the panel drawn by Head/Incharge of the concerned department.

(ii) In the case of the practical examination of the courses, the assessment shall be jointly under taken by the internal and external examiners. For the assessment of practical component, half of the examiners in the team shall be invited from outside the University from amongst the panel of examiners (ordinarily not below the rank of Associate Professor) approved by the competent authority.

(iii) In case of the Project reports, Thesis and Dissertation, the assessment shall be jointly carried out by the internal and external examiners. External examiners shall be invited from amongst the panel of examiners (ordinarily not below the rank of Associate Professor) approved by the competent authority.

(iv) The result of the students shall be subject to moderation by a Board of Moderators appointed by the University for each programme/course.

(v) Pattern of Question Papers in End-Semester Exams. for assessment and evaluation of students:

(a) Question no. 1 shall consist of short answer type questions of specific word length from all the units with internal choice. The questions shall be set in such a manner that the students shall have to attempt at least one short-answer type question from each unit.

(b) Students shall have to attempt one question from each unit and the question paper shall provide internal choice for each question to be attempted from each unit.

6. Re-appear Examination/Improvement of Grades

Re-appear Examination: The students failing to score minimum grade required to qualify a course/programme may be allowed to re-appear in those papers where they couldn't score 'P' grade in the extra semesters provided in Clause 7 on "Duration of Programme" with the following provisions:

(i) student securing "F" Grade in a course shall be permitted to repeat/ reappear in the End-Semester Examination of the Course for a maximum number of three times i.e. a student with arrears on account of "F" Grade, shall be permitted to repeat / reappear in the End

Semester Examination for a maximum of three times (including the first appearance), along with the subsequent End Semester Examinations.

(ii) If a student secures "F" Grade in a Project Work / Project Report/ Dissertation / Field Work Report / Training Report etc, he/she shall be required to resubmit the revised Project Work / Project Report/ Dissertation / Field Work Report / Training Report etc. as required by the evaluator(s). Provided further that a student shall be permitted to re-submit the Project Work / Project Report / Dissertation / Field Work Report/ Training Report etc. for a maximum of three times (including the first submission).

(iii) Such students may avail the chance to re-appear only within the maximum duration of the programme.

(iv) Re-appear examination of even semesters shall be conducted with the end-semester examinations of even semesters and similarly examinations of odd semesters shall be conducted with the end-semester examinations of odd semesters. However a student in the final semester is allowed to re-appear in the courses of both odd and even semesters.

(v) A 'Re-appear' examination shall be based on the syllabi of the course/programme in force at the time of initial registration to the course/programme.

(vi) A student who has got the migration certificate issued from the university shall not be allowed to re-appear at any examination.

7. Re-evaluation/Re-checking:

A student may apply for revaluation/rechecking of his/her answer scripts within thirty days of the declaration of the result.

(i) For re-evaluation/re-checking of the answer scripts, a student shall have to apply on the prescribed form available on the University website or the Examination Branch of the University, along with the original Detail Marks Certificate or the copy of the result sheet and a Fee of Rs. 1000/- for each Course/Paper.

(ii) (a) If after the first revaluation, the difference of the original marks and re-evaluated marks is up to plus or minus 5% of the maximum marks of the paper, there shall be no change in the marks originally scored by the student.

(b) If after the first re-evaluation, the difference of the original marks and re-evaluated marks is more than 5% and less than 10%, the average of the two scores will be considered as final score and the result shall be revised accordingly.

(c) If after the first re-evaluation, the difference comes to more than plus or minus 10% of the maximum marks of the paper, the answer script shall be re-evaluated by a third examiner.

(d) After the second re-evaluation, the average of the nearest two awards/marks shall be taken as final and result shall be revised accordingly.

8. Minimum Credit requirements:

(i) For a one-year Post Graduate programme, the credit requirements for the award of the Post Graduate Diploma shall be 52 credits (±4 Credits), including a minimum of 9 credits from the elective courses (of which at least 4 credits shall be from elective course offered by another Department).

(ii) For a two-year Master's Degree programme, the credit requirements for the Master's degree shall be 100 credits (±4 Credits), including a minimum of 18 credits from elective courses (of which at least 8 credits shall be from elective courses offered by other Departments).

(iii) For a three-year Master's programme, the credit requirements for the Master's degree shall be 150 credits (±6 Credits), including a minimum of 27 credits from elective courses (of which 12 credits shall be from elective courses offered by other Departments).

9. Computation of SGPA and CGPA

The University shall follow the following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

(i) The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and sum of the number of credits of all the courses undergone by a student, i.e.

$$\text{SGPA (Si)} = \sum(Ci \times Gi) / \sum Ci$$

where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

(ii) The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

$$\text{CGPA} = \sum(Ci \times Si) / \sum Ci$$

where Si is the SGPA of the i^{th} semester and Ci is the total no. of credits in that semester.

(iii) The SGPA and CGPA shall be rounded off to 2 decimal points.

10. Illustration of the Computation of SGPA and CGPA

(i) Illustration of Computation

Course	Credit	Grade Letter	Grade Point	Credit Point
Course I	3	A	8	3 x 8 = 24
Course II	4	B+	7	4 x 7 = 28
Course III	3	B	6	3 x 6 = 18
Course IV	3	O	10	3 x 10 =30

	Total credits for the semester=13			Total Credit points earned= 100

Thus, SGPA= 100/13= 7.69

(ii) Illustrations for computing CGPA:

Semester I	**Semester II**	**Semester III**	**Semester IV**	**Semester V**	**Semester VI**
Credit: 20	Credit: 22	Credit: 25	Credit: 26	Credit: 26	Credit: 25
SGPA: 6.9	SGPA: 7.8	SGPA: 5.6	SGPA: 6.0	SGPA: 6.3	SGPA= 8.0

Thus,

$$\text{CGPA} = \frac{((20 \times 6.9) + (22 \times 7.8) + (25 \times 5.6) + (26 \times 6.0) + (26 \times 6.3) + (25 \times 8.0))}{(20+22+25+26+26+25)}$$

= (969.4/144) =6.73

Note: Formula to calculate percentage from CGPA/SGPA= CGPA or SGPA x 10; and formula to calculate percentage to CGPA or SGPA = Percentage/10

e.g. In case of example mentioned in table 12.2, the percentage of CGPA = 6.73x10 =67.30.

(iii) **Transcript (Format):** Based on the above, letter grades, grade points, SGPA, and the CGPA, the Transcripts/Detail Marks Certificates (DMCs) shall be issued to the candidates for each semester and a consolidated transcript indicating the performance in all the semesters. The percentage of marks shall be reflected in the DMC of the final semester on the basis of the CGPA.

11. Removal of Student Name from the Programme:

(i) The name of a student falling under any one of the following categories shall automatically stand removed from the rolls of the University:

(a) A student who has failed to fulfil the minimum grade point requirements prescribed for the programme during the maximum duration of the programme.

(b) A student who has already exhausted the maximum duration allowed for completion of the Programme and has not fulfilled the requirements for the award of the degree /diploma.

(c) A student who is found to be involved in misconduct, forgery, indiscipline or any other objectionable conduct, upon recommendation of the Discipline Committee/ Proctorial Board, and

(d) A student who has failed to attend the classes as stipulated under Ordinance XV (II).

(ii) Promotion Rules

(a) A student will be promoted from an odd semester to the next even semester without any restrictions on the minimum number of credits earned. However for promotion from an even semester to the next odd semester, a student should have earned atleast 50% of the credits of the current and all previous semesters taken together. A student failing to earn atleast 50% of the credits from the prescribed courses of all present and all previous semesters taken together will be treated as an 'Ex-student' and will be allowed to repeat in the end semester examination of the previous semesters as applicable (for example for a student going from semester 4 to 5 who becomes an Ex. Student, he/ she shall be required to repeat all the papers of semester 3 and semester 4 in the next odd/even semester). However such student will not be allowed to repeat the internal assessment for the said paper/s of the respective semester/s as the case may be. After passing the said semesters, the student shall be promoted to the next odd semester and shall be treated as a 'Regular' student.

(b) A student shall be declared to have passed the programme of study and award of the degree if he/she has secured the required credits with at least 'P' grade.

12. KEYWORDS

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

13. REFERENCES

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf
- Ordinance-XV, Programmes leading to the award of Post Graduate degrees/Diplomas, Central University of Haryana.

14. APPENDICES

NIL