ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM

Affiliated to Mahatma Gandhi University, Kottayam

CURRICULUM FOR
M.Sc. MATHEMATICS

Under Credit & Semester System
(2025 Admissions Onwards)

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

BOARD OF STUDIES IN MATHEMATICS AND STATISTICS

LIST OF MEMBERS

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics (Aided), St. Teresa's College (Autonomous), Ernakulam (Chairperson).

2. **Dr. Angel Mathew**, Professor, Department of Statistics, Maharaja's College, Ernakulam (University Nominee).

3. **Dr. Asha Gopalakrishnan,** Senior Professor, Department of Statistics, CUSAT (Subject Expert).

4. **Dr. Linu Pinto**, Assistant Professor, Department of Mathematics, CUSAT (Subject Expert).

5. **Mr. Nasif N. M**, Evangelist and Community Lead, Kerala Startup Mission (Industry Expert).

6. **Ms. Teena Mary**, Data Analyst, impress.ai (Infopark), Kakkanad, Kochi (Alumnae Representative).

7. **Dr. Susan Mathew Panakkal**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

8. **Dr. Ursala Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

9. **Smt. Neenu Susan Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

10. **Ms. Parvathy T. S**., Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

11. **Ms. Parvathy P.S**., Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

12. **Smt. Anju N. B.**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

13. **Ms. Mariya Jessneela,** Guest Faculty, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

14. **Smt. Nisha Oommen**, HoD and Assistant Professor, Department of Mathematics and Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

15. **Smt. Betty Joseph**, Associate Professor (Retd.), Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

16. **Smt. Dhanalakshmi O.M**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

17. **Ms. Josmy Thomas**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

18. **Smt. Mary Andrews**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

19. **Ms. Vismaya Vincent**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

20. **Ms. Arunima P.S.**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

21. **Smt. Tania P.R**. Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

22. **Ms. Devika Shaji**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

23. **Ms. Jesna Babu**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

24. **Ms. Aksa Mathew**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

MINUTES OF THE BOARD OF STUDIES MEETING OF THE DEPARTMENT OF MATHEMATICS AND STATISTICS HELD ON 14-03-2025

This is to certify that the revised syllabus of the M.Sc. Mathematics for 2025 admissions onwards has been scrutinized and approved at the Board of Studies Meeting which was held on 14-03-2025. The complete revised syllabus of M.Sc. Mathematics programme was presented before the Board of Studies and discussed in detail. The revised syllabus was approved by the Board of Studies.

The following members attended the meeting.

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics (Aided), St. Teresa's College (Autonomous), Ernakulam (Chairperson).

2. **Dr. Angel Mathew**, Professor, Department of Statistics, Maharaja's College, Ernakulam (University Nominee).

3. **Dr. Asha Gopalakrishnan,** Senior Professor, Department of Statistics, CUSAT (Subject Expert).

4. **Dr. Linu Pinto**, Assistant Professor, Department of Mathematics, CUSAT (Subject Expert).

5. **Mr. Nasif N. M**, Evangelist and Community Lead, Kerala Startup Mission (Industry Expert).

6. **Ms. Teena Mary**, Data Analyst, impress.ai (Infopark), Kakkanad, Kochi (Alumnae Representative).

7. **Dr. Susan Mathew Panakkal**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

8. **Dr. Ursala Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

9. **Smt. Neenu Susan Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

10. **Ms. Parvathy T. S.**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

11. **Ms. Parvathy P.S.**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

12. **Smt. Anju N. B.**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

13. **Ms. Mariya Jessneela,** Guest Faculty, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

14. **Smt. Nisha Oommen**, HoD and Assistant Professor, Department of Mathematics and Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

15.**Smt. Betty Joseph**, Associate Professor (Retd.), Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

16. **Smt. Dhanalakshmi O.M**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

17. **Ms. Josmy Thomas**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

18. **Smt. Mary Andrews**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

19. **Ms. Vismaya Vincent**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

20. **Ms. Arunima P.S.**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

21. **Smt. Tania P.R**. Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

22. **Ms. Devika Shaji**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

23. **Ms. Jesna Babu**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

24. **Ms. Aksa Mathew**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

FACULTY OF THE DEPARTMENT WHO HAVE CONTRIBUTED TOWARDS CURRICULUM AND SYLLABUS IN M.Sc. MATHEMATICS

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics (Aided), St. Teresa's College (Autonomous), Ernakulam.

2. **Dr. Susan Mathew Panakkal**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

3. **Dr. Ursala Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

4. **Smt. Neenu Susan Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

5. **Ms. Parvathy T. S**., Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

6. **Ms. Parvathy P.S**., Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

7. **Smt. Anju N. B.**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College (Autonomous), Ernakulam.

8. **Ms**. **Mariya Jessneela,** Guest Faculty, Department of Mathematics (aided), St. Teresa's College (Autonomous), Ernakulam.

9. **Smt. Nisha Oommen**, HoD and Assistant Professor, Department of Mathematics and Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

10. **Smt. Betty Joseph**, Associate Professor (Retd.), Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

11.**Smt. Dhanalakshmi O.M**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

12. **Ms. Josmy Thomas**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

13. **Smt. Mary Andrews**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

14. **Ms. Vismaya Vincent**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

15. **Ms. Arunima P.S**., Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

16. **Smt. Tania P.R**. Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

17. **Ms. Devika Shaji**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

18. **Ms. Jesna Babu**, Assistant Professor, Department of Statistics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

19. **Ms. Aksa Mathew**, Assistant Professor, Department of Mathematics (Self Financing), St. Teresa's College (Autonomous), Ernakulam.

ACKNOWLEDGEMENT

I acknowledge with gratitude all the guidance and help given by our Directors, Rev. Sr. Tessa CSST and Rev. Sr. Francis Ann CSST and Principal, Prof. Dr. Alphonsa Vijaya Joseph during the course of restructuring the syllabus of M.Sc. Mathematics. I also remember and acknowledge with gratitude all the members of the Board of Studies for their constructive suggestions and contributions in restructuring all the courses of this Masters Programme. I thank Smt. Nisha Oommen Coordinator of the PG syllabus restructuring in Mathematics. I thank all the faculty members of the Department, for taking great effort to prepare this syllabus. I am also grateful to all the members of the Curriculum Committee of the college for their guidance during the syllabus framing process. Above all, I bow my head before God Almighty for all the guidance he has continuously given to us in all our endeavours.

Dr. Elizabeth Reshma M.T,

HoD, Department of Mathematics and Statistics.

CHAIRMAN
BOARD OF STUDIES OF MATHEMATICS AND STATISTICS

PREFACE

As an autonomous institution under Mahatma Gandhi University, St. Teresa's College is committed to enhancing its curriculum while adhering to the essential guidelines set by the University and Higher Education Council. Our aim is to cultivate a well-rounded educational experience. Within the framework of the prescribed syllabi, we have unified our efforts to foster an inspiring academic environment that empowers both teachers and students to delve deeper into knowledge and contribute to its dissemination and growth. It is crucial to emphasize that the generation and sharing of Quality Knowledge—which is vital for the growth and development of students and society as a whole—constitute the core mission of any educational institution.

The revised syllabi of our programs are designed in such a way to offer students innumerable opportunities for authentic, real-world learning experiences that will enhance their reasoning, creativity, intelligence and problem-solving abilities. This approach will enable them to attain knowledge of universal significance and relevance, fostering personal growth, civic responsibility, economic proficiency and the overall welfare of community, society and world at large.

We would like to acknowledge the dedication of our teachers in restructuring the syllabi and defining course outcomes that prioritize the cognitive and intellectual development of our learners. This initiative instils the confidence necessary for them to conduct independent and scholarly research in their areas of professional interest, positioning them as effective global cross-cultural educators.

We extend our congratulations to Prof. Dr. Alphonsa Vijaya Joseph, Principal, Dr. Kala M.S., Dean of Self Financing, Dr. Mary Liya C.A, Faculty Coordinator for syllabus revision, who have effectively coordinated the syllabus restructuring across all programs. We strive to transform lives and make a meaningful impact both locally and globally through the creation, sharing, and application of knowledge. We look forward to sharing the outcomes of our curriculum restructuring and hope that these resources will inspire reflection on the advancements in learning within our institution, as well as contribute to the global educational landscape.

Sr. Tessa CSST & Sr. Francis Ann CSST

Directors, St. Teresa's College

FOREWORD

Autonomy in higher education signifies a commitment to responsibility and accountability, which ultimately fosters excellence in academics and proactive governance. St. Teresa's College was granted autonomous status in 2014, and since then, we have made concerted efforts to uphold a high standard of quality in the education we provide. In 2019, the college achieved re-accreditation by NAAC with an A ++ grade (CGPA 3.57).

This academic autonomy has empowered us to refine our syllabus to meet the evolving needs of today's students. The current educational landscape presents numerous challenges, and it is essential that our curricula and syllabi reflect the significant shifts occurring across various disciplines. To this end, we have gathered structured feedback from students, alumni and industry experts, incorporating their suggestions into our syllabi.

Our Board of Studies, established for each department, meets regularly within the designated time frame to engage in thorough discussions regarding various aspects of the curricula and syllabi. The IQAC team has facilitated numerous workshops and conferences to equip our faculty with the necessary skills to design syllabi and formulate question papers for internal assessments, ensuring that the learning outcomes outlined in the syllabus are met and that examinations are conducted fairly and transparently.

The responsibilities that come with our autonomy are indeed substantial, but we have united in our efforts to tackle the challenges that arise. Our focus has been on shaping young women into responsible citizens who will contribute to nation-building in exemplary ways. To enhance industry-academia linkage and ensure students are placement-ready, the curriculum will emphasize the importance of internships and application-oriented research projects, fostering a sense of social responsibility and equipping students with practical skills to facilitate entrepreneurship. We are dedicated to nurturing their academic aspirations alongside their skills in co-curricular activities. To align with the needs of the new generation of students, we plan to restructure our postgraduate programs in the upcoming academic year.

I extend my heartfelt gratitude for the unwavering support and guidance provided by Rev. Sr. Tessa CSST and Rev. Sr. Francis Ann CSST, the Directors of the College. I would also like to express my special thanks to the team led by Dr. Kala M.S and Dr. Mary Liya C.A. for coordinating the syllabus restructuring of our programs, as well as to the Heads of Departments and all faculty members for their dedication, commitment and exceptional contributions to this important initiative.

PROF. ALPHONSA VIJAYA JOSEPH
PRINCIPAL

CONTENTS

		Page No.
1.	**Preamble**	**12**
2.	**Programme Outcomes (POs)**	**13**
3.	**Programme Educational Objectives (PEO)**	**15**
4.	**Programme Specific Outcome (PSO)**	**16**
5.	**Structure of M.Sc. Mathematics**	**18**
6.	**Distribution of Courses and credits**	**20**
	Core Courses	**20**
	Elective Courses	**21**
	Distribution of credits	**21**
7.	**Evaluation and Grading**	**22**
	In Semester Assessment	**23**
	End Semester Assessment	**26**
	Computation of CGPA	**30**
8.	**Syllabi for Courses**	**32**
	Core Courses	**33**
	Elective Courses	**101**

PREAMBLE

The aim of the Postgraduate education is to provide high quality education as well as a supportive learning environment for the students to reach their full academic potential. The higher education has to inculcate in students the spirit of hard work and research aptitude to pursue further studies in the nationally/internationally reputed institutions as well as prepare them for a wider range of career opportunities in interdisciplinary fields.

The Board of Studies in Mathematics has restructured the syllabi for M.Sc. Mathematics so as to monitor, review and enhance educational experience which ensures that the Post Graduate Education remains intellectually demanding and relevant to current needs of Mathematics graduates. The thrust is given in fostering a friendly and stimulating learning environment which will motivate the students to reach high standards, enable them to acquire real insight into Mathematics and become self-confident, committed and adaptable graduates. With this in mind, we aim to provide a firm foundation in every aspect of Mathematics and to develop analytical, experimental, computational, logical and reasoning skills of students.

The Board of Studies acknowledges and appreciates the good effort put in by the faculty members of the Department of Mathematics to restructure the syllabus for M.Sc. Mathematics in the institution which will be implemented for the admissions from 2025 onwards.

PROGRAMME OUTCOMES (POs) OF POSTGRADUATE PROGRAMMES:

The integration of Outcome-Based Education (OBE) stands as a cornerstone of the postgraduate programmes at St. Teresa's College (Autonomous), Ernakulam, with the Programme Outcomes (POs) intricately aligned to the vision and mission of the college. By adopting OBE, the institution meticulously cultivates graduates who are not only equipped with advanced knowledge and critical skills but are also adept in addressing professional challenges, contributing to society, and embracing lifelong learning, thereby fostering well-rounded, responsible individuals committed to excellence in their fields. The POs for the post graduates of St. Teresa's college are listed below:

PO1: Advanced Knowledge and Application

Graduates will demonstrate an advanced and integrated understanding of their discipline, to effectively apply this knowledge to solve complex, real-world challenges, showing originality in developing innovative solutions that contribute to their field and to society.

PO2: Critical Thinking and Analytical Skills

Graduates will critically evaluate complex problems, synthesize information from diverse sources, and employ advanced analytical reasoning to formulate evidence-based solutions in line with contemporary needs.

PO3: Research and Innovation

Graduates will be able to conduct independent, original research using appropriate scientific or creative methodologies, thereby contributing new knowledge or insights to implement innovative practices and provide solutions to the issues of the contemporary world.

PO4: Interdisciplinary and Collaborative Skills

Graduates will collaborate effectively in interdisciplinary and multicultural teams, leveraging the strengths of various disciplines to address multifaceted problems, reflecting the global best practice of professionals who can operate in diverse group settings.

PO5: Communication Skills

Graduates will be skilled in articulating their ideas, research findings, and solutions clearly and effectively in both oral and written formats, ensuring engagement and understanding across diverse audiences.

PO6: Technological Proficiency and Innovation

Graduates will be proficient in using modern technologies and digital tools relevant to their field, applying technological innovations to enhance research, professional practice, and societal well-being, and ensuring they remain at the cutting edge of their discipline.

PO7: Global Awareness and Societal Engagement

Graduates will integrate knowledge of global trends, cultural diversity, and sustainable development principles into their work, actively engaging with society to promote inclusivity, equity, and environmental stewardship in line with global citizenship values.

PO8: Ethical and Professional Responsibility

Graduates will uphold the highest standards of ethics and professionalism in all their academic and professional endeavours and will make informed decisions that reflect integrity and ethical consideration, including respect for diverse perspectives and awareness of the social and environmental implications of their actions.

PO9: Advocacy for Social Justice and Inclusive Development

Graduates will leverage their knowledge, skills, and experiences to advocate for social justice, equality, and the empowerment of marginalized communities, engaging in initiatives that promote inclusive and sustainable development, thereby contributing to the well-being of society

PO10: Lifelong Learning and Professional Development

Graduates will embrace a mindset of lifelong learning, continually adapting to new technologies and societal needs by proactively seeking new learning opportunities and adapt to emerging technologies and evolving industry trends, engaging in ongoing professional development to remain at the forefront of their field.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The M.Sc. Mathematics programme prepares graduates to achieve key objectives within a few years of completion, focusing on professional success, societal contributions, and lifelong learning. The Programme Educational Objectives (PEOs) M.Sc. Mathematics programme, outlined below, are designed to equip graduates with the skills and knowledge for continued growth and advancement in the field of Mathematics.

PEO 1: Graduates will engage in impactful research, and contribute to the development of mathematical sciences at national and international levels.

PEO 2: Graduates will effectively apply advanced mathematical knowledge and computational skills in industries such as finance, data analytics, artificial intelligence, machine learning and software development.

PEO 3: Graduates will possess the skills to develop innovative and data-driven solutions to address complex societal challenges in diverse fields leveraging advanced mathematical techniques.

PROGRAMME SPECIFIC OUTCOMES

The Department of Mathematics is committed to provide an enriched educational experience to develop the knowledge, skills and attributes of students to equip them for life in a complex and rapidly changing world.

On completion of the M.Sc. Mathematics, our students should be able to demonstrate the programme specific outcomes listed below:

PSO 1: Explain the advanced mathematical concepts in the core areas like Analysis, Algebra, Topology, Differential Equations and Graph Theory to solve theoretical and applied problems. (An)

PSO 2: Analyze real life problems by integrating concepts from Optimization, Number Theory, and Cryptography, with applications in secure communications and algorithm design. (An)

PSO 3: Apply mathematical software and programming tools to model, simulate, and solve complex real-world problems, with a focus on numerical analysis and computational efficiency. (A)

PSO 4: Evaluate foundational concepts of Linear Algebra for implementing Machine Learning algorithms, facilitating efficient data representation and dimensionality reduction(E)

PSO 5: Integrate research-driven approaches with mathematical tools to conduct independent investigations in diverse fields. (C)

Job Opportunities

An M.Sc. in Mathematics opens doors to a wide range of job opportunities in academia, finance, data science, technology, and beyond. Graduates can pursue research or teaching roles, work as quantitative analysts, actuaries, statisticians, or risk analysts in financial institutions. In the tech industry, roles such as cryptographer, algorithm engineer, and software developer are in demand. The degree provides a strong foundation for analytical, problem-solving, and research-oriented roles across various industries.

Eligibility for admission

Graduation in Mathematics/ Statistics / Computer Application with not less than CGPA of 2.00 out of 4. 00 in the Core Group (Core + Complementary + Open Courses)

OR

Graduation in Mathematics/ Statistics / Computer Application with not less than CCPA of 5.00 out of 10. 00 in the Core Group (Core + Complementary + Open Courses)

OR

Graduation in Mathematics/ Statistics /Computer Application with not less than 50% marks in the Part III subjects (Main/Core + subsidiaries/Complementaries)

OR

B Tech with not less than 50% marks in mathematics (aggregate of all mathematics papers and a total of 50% for the entire course)

Duration of the Programme: Four Semesters

Examination:

Credit and Semester system (CSS)

Direct Grading system with 7 - point scale

Medium of instruction and assessment: English

Faculty under which the Degree is awarded: Faculty of Science

PROGRAMME STRUCTURE

STRUCTURE OF M. Sc. MATHEMATICS

The programme shall include two types of courses, Core courses and Elective courses. There shall also be a Project and Comprehensive Viva Voce as core courses. The programme also includes assignment/ seminar/ Class tests etc. The total credit for the programme is fixed at 80.

THEORY COURSES:

There are **nineteen** theory courses spread in four semesters in the M.Sc. Programme. Distribution of theory courses is as follows. There are **sixteen** core courses common to all students. Semester I, Semester II and Semester III will have **five** core courses each and Semester IV will have **one** core course, **three** elective core courses and a project. The **three** elective core courses can be chosen as per the interest of the students, availability of faculty and academic infrastructure.

PROJECT

The project of the PG program should be relevant and innovative in nature. The type of project can be decided by the student and the guide (a faculty of the department or other department/ college/ university/ institution). The project work should be taken up seriously by the student and the guide. The project should be aimed to motivate the inquisitiveness and research aptitude of the students. The students may be encouraged to present the results of the project in seminars/symposia. The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV. The project is evaluated by one external and one internal examiner.

COMPREHENSIVE VIVA VOCE

A comprehensive viva voce examination will be conducted by one external and one internal examiner at the time of evaluation of the project. The components of viva consist of subjects of special interest, fundamental concepts, topics covering all semesters and awareness of current and advanced topics.

COURSE CODE

The courses in the programme are coded according to the following criteria. The first two letters of the code indicate the name of programme, ie. MT stands for Mathematics. Next digit is to indicate the semester. i.e., MT1 (Mathematics, 1st semester). This is followed by the letter C or E indicating whether the course is a core course or elective course as the case may be. (However, in the case of Project/Comprehensive viva voce this letter is omitted.) Next two digits indicate the course number (avoided in the case of Project/Comprehensive viva voce). The letter/letters T/P/ PR/V follows it and is used to indicate theory/ practical/ project/ viva. The next letter will be M which indicates that the programme is for masters. The last two digits 25 represent the year in which restructuring is done.

Example: Theory- MT1C01TM25.

DISTRIBUTION OF COURSES AND CREDITS

Semester	Course Code	Course Title	Teaching hours per week	Credit	Total credit
I	MT1C01TM25	Linear Algebra	5	4	20
	MT1C02TM25	Basic Topology	5	4	
	MT1C03TM25	Real Analysis	5	4	
	MT1C04TM25	Abstract Algebra	5	4	
	MT1C05TM25	Graph Theory	5	4	
II	MT2C06TM25	Complex Analysis	5	4	20
	MT2C07TM25	Functional Analysis	5	4	
	MT2C08TM25	Field Theory	5	4	
	MT2C09TM25	Numerical Analysis with Python	5	4	
	MT2C10TM25	Research Methodology	5	4	
III	MT3C11TM25	Spectral Theory	5	4	20
	MT3C12TM25	Measure Theory and Integration	5	4	
	MT3C13TM25	Linear Algebra for Machine Learning	5	4	
	MT3C14TM25	Partial Differential Equations	5	4	
	MT3C15TM25	Advanced Graph Theory	5	4	
IV	MT4C16TM25	Optimization Techniques	5	4	20
		Elective 1	5	3	
		Elective 2	5	3	
		Elective 3	5	3	
	MT4PRM25	**Project/Dissertation**	5	5	
	MT4VM25	**Viva-Voce**		2	
	TOTAL				80

ELECTIVE COURSES:

Course code	Course Title	Teaching hours per week	Credit
MT4E01TM25	Advanced Complex Analysis	5	3
MT4E02TM25	Number Theory and Cryptography	5	3
MT4E03TM25	Differential Geometry	5	3
MT4E04TM25	Multivariate Calculus and Integral Transforms	5	3
MT4E05TM25	Combinatorics	5	3
MT4E06TM25	Analytic Number Theory	5	3
MT4E07TM25	Operations Research	5	3
MT4E08TM25	Probability Theory	5	3
MT4E09TM25	Coding Theory	5	3

ELECTIVE (Credit 3*3=9)		
GROUP A	**GROUP B**	**GROUP C**
Advanced Complex Analysis	Multivariate Calculus and Integral Transforms	Operations Research
Number Theory and Cryptography	Combinatorics	Probability Theory
Differential Geometry	Analytic Number Theory	Coding Theory

DISTRIBUTION OF CREDITS:

The total credit for the programme is fixed at 80. The distribution of credit points in each semester and allocation of the number of credits for theory courses, project and viva is as follows. The credit of theory courses is 4 per course in the first, second and third semesters. The core courses in the fourth semester will have 4 credits and elective core courses will have 3 credits. The project will have a credit of 5 and viva voce a credit of 2. The distribution of credit is shown below.

Semester	Courses	Credit	Total Credits
I	5 Theory Core Courses	4	5 X 4 = 20
II	5 Theory Core Courses	4	5 X 4 = 20
III	5 Theory Core Courses	4	5 X 4 = 20
IV	1 Theory Core Course	4	1 X 4 = 4
	3 Theory Elective Core Courses	3	3 X 3 = 9
	1 Project / Dissertation	5	1 X 5 = 5
	1 Viva Voce	2	1 X 2 = 2
GRAND TOTAL			80

EVALUATION AND GRADING

The evaluation for each course shall contain two parts such as In-Semester Assessment (ISA) and End Semester Assessment (ESA). The ratio between ISA and ESA shall be 1:3 and 25% weightage shall be given to ISA and 75% to ESA. Both ISA and ESA shall be carried out using a direct grading system.

Evaluation (Both ISA and ESA) to be done by the teacher is based on a Six-point scales shown in the table below:

GRADE	GRADE POINT	RANGE
A^+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

Direct Grading System based on a 7 – point scale is used to evaluate the performance of students in both ISA and ESA.

For all courses (theory & practical), semester/ overall programme, the letter grades for **GPA/SGPA/CGPA** and its indicators are given in the following table.

RANGE	GRADE	INDICATOR
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
0.00 to 1.99	D	Deficient (Fail)

IN-SEMESTER ASSESSMENT (ISA)

The In Semester Assessment is to be done by continuous assessments of the components given below. The components of ISA for theory and their weightage are as in the following tables.

THEORY	
COMPONENTS	**WEIGHTAGE**
Assignment	2
Seminar	4
Test Papers (Average of 2)	4
TOTAL	**10**

The two test papers in the Theory component should be in the same model as the ESA question paper. For test papers, questions shall be set in such a way that the answers can be awarded A^+, A, B, C, D or E grade.

The performance of students in the seminar and assignment should also be documented in terms of grades.

The components for assignments and seminars are as in the following table:

ASSIGNMENT COMPONENTS	SEMINAR COMPONENTS
Punctuality	Content
Content	Presentation

The components of ISA for the project and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
TOTAL	**5**

The ISA of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the end of Semester II. The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in students the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of two students may be allowed to perform one project work if the volume of the work demands it. Project evaluation begins with (i) The selection of problem, (ii) Literature survey, (iii) Work plan, (iv) Experimental / theoretical setup/data collection, (v) Characterization techniques/ computation/ analysis (vi) Use of modern software for data analysis/experiments (Python, MATLAB, ...etc) and (vi) Preparation of project report. The project internal grades are to be submitted at the end of Semester IV.

The components of ISA for comprehensive viva voce and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Fundamental concepts	3
Awareness of current /advanced topics	2
TOTAL	**5**

GENERAL INSTRUCTIONS FOR ISA

- The In-Semester assessment should be fair and transparent. The responsibility of evaluating the ISA is vested on the teacher(s) who teach the course. The evaluation of the components should be published and acknowledged by students.
- The assignments/ seminars / test papers are to be conducted at regular intervals. These should be marked and promptly returned to the students.
- One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheets for ISA in the department in the format provided by the Controller of the examinations. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for ESA. The grade sheet should be signed by the coordinator and counter signed by the Head of the Department and the Principal.
- There shall be no separate minimum grade point for ISA of theory, practical, project and comprehensive viva voce. Though no separate minimum is required for internal evaluation for a pass, a minimum C grade is required for a pass in an external evaluation. And a minimum C grade is required for a pass in a course.
- The consolidated grades in specific format are to be kept in the college for future references for 2 years. The consolidated grades in each course should be uploaded to the Institution Portal at the end of each semester as directed by the Controller of Examinations.
- There shall not be any chance for the improvement of ISA grade points.

Grievance Redressal Mechanism for ISA

There will be provision for grievance redressal at three levels, viz,

1. At the level of teacher concerned,
2. At the level of departmental committee consisting of Head of the Department, Coordinator and teacher concerned,
3. At the level of college committee consisting of the Principal, Controller of Examinations and Head of the Department.

END SEMESTER ASSESSMENT (ESA)

The End Semester Assessment of all semesters shall be conducted by the institution on the close of each semester. The End Semester Assessment will be of 3 hours duration for each lecture-based course. A minimum C grade is required for a pass in ESA. Also, in aggregate a minimum C grade is required for a pass in a course.

Students with less than 73% aggregate attendance during a semester are not eligible to attend ESA of any course.

If a student represents her Institution/ University / State/ Nation in Sports /NCC/ NSS or Cultural or any other officially sponsored activities such as college union/university union etc, she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 15 days in a semester based on the specific recommendations of the Head of the Department or teacher concerned.

For reappearance/ improvement, students may appear along with the next batch.

However, the students who fail in semester 3 will have the opportunity to appear for a special supplementary (SAVE AN YEAR – SAY) examination conducted at the end of Semester 3.

QUESTION PAPER PATTERN FOR THEORY COURSES.

All the theory question papers are of three-hour duration. All question papers will have three parts. The question shall be prepared in such a way that the answers can be awarded the grades A+, A, B, C, D or E.

The questions in each section will be grouped according to the Course Outcomes (COs), with the selection of questions to be answered falling under a single CO. Thus, the mandatory attempt of all COs can be ensured for the calculation of course outcome attainment.

Part A: Questions in Part A are very short answer type. A total of eight questions needs to be answered, each carrying a weightage of 1, contributing to a cumulative weightage of 8 for the section.

For courses with 4 COs, there will be 4 bunches of 3 questions each, assigned to each CO, and students must answer 2 questions from each bunch.

Part B: Part B consists of problem solving and short essay type questions related to the course. A total of six questions needs to be answered, each carrying a weightage of 2, contributing to a cumulative weightage of 12 for the section.

For courses with 4 COs, there will be 2 bunches of 4 questions each, assigned to those COs not assessed in Part C, and students must answer 3 questions from each bunch.

Part C: Part C will have four questions, grouped into two bunches, with each bunch containing two questions related to the same CO. Students must answer one question from each set. Each question will carry a weightage of 5, contributing to a total weightage of 10 for Part C.

Maximum weightage for End-Semester Assessment is 30. Therefore, Maximum Weighted Grade Point (WGP) is 150.

DIRECTIONS FOR QUESTION SETTERS:

1) Questions shall be set to assess knowledge acquired, standard and application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge.
2) Due weightage shall be given to each module on content/teaching hours allotted to each module.
3) The question setter shall ensure that questions are set as per the course outcomes.
4) A question paper shall be a judicious mix of short answer type, short essay type/problem solving type and long essay type questions.
5) The questions shall be set in such a way that the answers can be awarded A^+, A, B, C, D or E grade.
6) Different types of questions shall be given different weightage to quantify their range as shown below:

Sections	Type of Questions	Weightage	No. of COs	Number of questions to be answered (CO*- COs assessed in Part C)
Part A	Short Answer type	1	4	2 out of 3 from each CO bunch
Part B	Short essay/ problem solving type	2	4	3 out of 4 from each CO bunch
Part C	Long Essay type	5	4	1 out of 2 from each CO* bunch

BLUEPRINT (For Courses with 4 COs / 90 hours)

CO	Part A Weight 1 each (Total weights=8)	Part B Weight 2 each (Total weights =12)	Part C Weight 5 each (Total weights = 10)	Total Weights (30 out of 48)
	Part Ai (2 out of 3 questions of each CO)	Part Bi (3 out of 4 questions of a given CO)	Part Ci (1 out of 2 questions of a given CO)	
CO1	3	0/0/0/4/4/4	2/2/2/0/0/0	13/13/13/11/11/11
CO2	3	0/4/4/0/0/4	2/0/0/2/2/0	13/11/11/13/13/11
CO3	3	4/0/4/0/4/0	0/2/0/2/0/2	11/13/11/13/11/13
CO4	3	4/4/0/4/0/0	0/0/2/0/2/2	11/11/13/11/13/13

Part A will contain section Ai (A1 to A4)

Part B will contain Bi sections (B1-B2)

Part C will contain Ci sections (C1 to C2)

- COs assessed in Part C (Essay) will not appear in Part B section.
- The blueprint models are numbered as BP_1 to BP_6 denoted by each slash in the table

PROJECT AND VIVA VOCE EXAMINATIONS

PROJECT EVALUATION

The project is evaluated by one external and one internal examiner. The project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/ findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the head of the department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project. The different weightage for assessment of different components is shown in the following table.

COMPONENTS	WEIGHTAGE
Relevance of the topic and analysis	2
Project content and presentation	10
Project viva	3
TOTAL	**15**

COMPREHENSIVE VIVA- VOCE EXAMINATION

Viva-voce shall be conducted by one external and one internal examiner at the time of evaluation of the project.. The viva-voce shall cover questions from all courses in the programme.

The components of the ESA for comprehensive viva- voce and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Fundamental concepts	9
Awareness of current topic/advanced topic	6
TOTAL	**15**

REAPPEARANCE / IMPROVEMENT

● A student who fails to secure a minimum grade (Grade C) for a pass in a course will be permitted to write the examination along with the next batch.

● The candidate who wishes to improve the grade/grade point of the End-Semester Assessment of a course / courses she has passed can do the same by appearing in the End-Semester Assessment of the semester concerned along with the immediate junior batch. This facility is restricted to the first and second semesters of the programme.

● There shall be supplementary examinations (no improvement) for the third semester.

PROMOTION

● A student who registers for a particular semester examination shall be promoted to the next semester.

● A student having 73% attendance and fails to register for examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided application for notional registration shall be submitted within 15 days of the commencement of the next semester.

COMPUTATION OF GPA/SGPA/CGPA

Grade Point Average (GPA): ISA and ESA are separately graded using a six point scale and the combined grade point with weightage 1 for ISA and 3 for ESA shall be applied to calculate the grade point average (GPA) of each course.

The Semester Grade Point Average (SGPA): After the successful completion of a semester SGPA of a student in that semester is calculated using the formula given below.

Semester Grade Point Average (SGPA) = $\frac{\sum(C_i \ X \ GPA_i)}{\sum C_i} \frac{\sum(C_i \ X \ GPA_i)}{\sum C_i}$ where C_i and GPA_i are the credit point and GPA of each course respectively.

Cumulative Grade Point Average (CGPA) for the programme is calculated as follows:

CGPA = $\frac{\sum(C_i \ X \ SGPA_i)}{\sum C_i} \frac{\sum(C_i \ X \ SGPA_i)}{\sum C_i}$ where C_i and $SGPA_i$ are the total credit point and SGPA of each semester respectively.

Note: A minimum of **C** Grade for ESA (for both theory and practical) is required for pass for a course. For a pass in a programme, a separate minimum of Grade **C** is required for all the individual courses. If a candidate secures **D** Grade for any one of the courses offered in a Semester/Programme, only **D** grade will be awarded for that Semester/Programme until she improves this to **C** grade or above within the permitted period.

Note: On compliance with the UGC minimum standards for the conduct and award of postgraduate degrees: Credit and semester system is followed in this program. The program has 4 semesters with eighteen weeks in each semester. In each semester there are 450 hours including both lecture and practical hours which is in compliance with the minimum 390 hours stipulated by the UGC.

All Rules and regulations are subject to change as and when modified by MG University to which St Teresa's College (Autonomous) is affiliated.

SYLLABI FOR THE COURSES OF

M. Sc. MATHEMATICS

CORE COURSES

SEMESTER I

SEMESTER I

CORE COURSE

MT1C01TM25 – Linear Algebra

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Examine fundamental concepts of Vector spaces, subspaces, basis, dimension and coordinates. (A)

CO2: Apply the properties of linear transformations, matrix representations, linear functionals, double dual spaces, and the transpose of linear transformations. (A)

CO3: Compute eigenvalues and eigenvectors of linear transformations and explain simultaneous triangulation and diagonalization. (A)

CO4: Explain Direct Sum Decompositions, Invariant Direct Sums and Primary Decomposition Theorem. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	2	2	2
CO2	2	1	2	2	2
CO3	2	1	2	2	2
CO4	3	1	2	2	2

Syllabus Content

Module I (CO1) **(20 hours)**

Vector Spaces: Vector spaces, subspaces, basis and dimension, Co-ordinates, summary of row-equivalence
(Chapter 2 - 2.1, 2.2, 2.3 (Proof of theorems excluded), 2.4 & 2.5 of the text)

Module II (CO2) **(25 hours)**

Linear Transformations: Linear Transformations, The Algebra of Linear Transformations, Isomorphism, Representation of Transformations by Matrices, Linear Functionals, The Double Dual, The Transpose of a Linear Transformation.
(Chapter 3 - 3.1 to 3.7 of the text)

Module III (CO3) **(20 hours)**

Elementary Canonical Forms: Introduction, Characteristic Values, Annihilating Polynomials, Invariant Subspaces, Simultaneous Triangulation, Simultaneous Diagonalisation.
(Chapter 6 - 6.1 to 6.5 of the text)

Module IV (CO4) **(25 hours)**

Decompositions: Direct Sum Decompositions, Invariant Direct Sums, The Primary Decomposition Theorem.
(Chapter 6 - 6.6 to 6.8 of the text)

- As part of the assignment, students are required to maintain an assignment book. This book should cover topics such as cyclic subspaces and annihilators, cyclic decomposition and rational form, the Jordan form, and related problems.

Learning Resources:

Text Books:

Kenneth Hoffman / Ray Kunze (Second Edition), Linear Algebra, Prentice-Hall of India Pvt. Ltd., New Delhi, 1992.

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.
2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
5. S. Kumaresan, Linear Algebra: A Geometrical Approach, Prentice Hall of India, 2000.
6. I. N. Herstein, Topics in Algebra; Wiley Eastern Ltd Reprint; 1991

7. P. R. Halmos, Finite Dimensional Vector spaces; Narosa Pub House, New Delhi; 1980
8. A. K. Hazra, Matrix: Algebra, Calculus and generalised inverse- Part I; Cambridge International Science Publishing; 2007
9. S. Lang: Linear Algebra; Addison Wesley Pub.Co.Reading, Mass; 1972
10. S. Maclane and G. Birkhoff: Algebra; Macmillan Pub Co NY; 1967
11. N. H. McCoy and R. Thomas: Algebra; Allyn Bacon Inc NY; 1977
12. R. R. Stoll and E.T.Wong: Linear Algebra; Academic Press International Edn; 1968
13. G. Strang: Linear Algebra and Its Applications (4th edn.); Thomson Learning, Inc. 2006

Blueprint

MT1C01TM25 – Linear Algebra

Blueprint model BP 3

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	PartC C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO2	CO3	CO1	CO4	
Module I 20 hrs	CO1	3	0	0	0	0	0	2	0	13
Module II 25 hrs	CO2	0	3	0	0	4	0	0	0	11
Module III 20 hrs	CO3	0	0	3	0	0	4	0	0	11
Module IV 25 hrs	CO4	0	0	0	3	0	0	0	2	13

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 3)

MT1C01TM25 – Linear Algebra

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Determine whether the set of all Hermitian matrices is a subspace of the space of all n x n matrices over C.	CO1	A
2.	Write a basis for the vector space of all polynomial functions from F to F of degree at most 5.	CO1	A
3.	Explain ordered basis and coordinate matrix relative to ordered basis.	CO1	A

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Explain rank and nullity of a linear transformation.	CO2	A
5.	A linear transformation T is non singular if and only if T is one-one. Illustrate.	CO2	A
6.	Let V be a finite dimensional vector space over the field F. Establish that each basis for V* is the dual of some basis for V.	CO2	A

(2 x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Similar matrices have the same characteristic polynomial. Explain.	CO3	A
8.	Suppose that Tα = cα . If f is any polynomial, then f(T)α = f(c)α . Illustrate.	CO3	A
9.	Explain invariant subspaces of a vector space	CO3	A

(2 x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Explain the significance of independence of subspaces of a vector space.	CO4	An
11.	Let E be a projection and let R be the range of E and N be the null space of E. Conclude that the vector β is in the range R if and only if Eβ = β.	CO4	An
12.	Any projection E is trivially diagonalizable. Illustrate	CO4	An

(2 x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO2. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Establish rank – nullity theorem.	CO2	A
14.	If V and W are finite dimensional vector space over a field F, then V and W are isomorphic if and only if dim V = dim W. Explain.	CO2	A

15.	Compute the matrix of T in the standard ordered basis of R^3 where T is a linear operator on R^3 defined by T (x_1,x_2,x_3) = $(3x_1 + x_3,\ -2x_1 + x_2,\ -x_1 + 2x_2 + 4x_3)$.	CO2	A
16.	Let T be a linear transformation from V into W where V and W are finite dimensional vector spaces over the field F. Establish that rank (T^t) = rank (T).	CO2	A

(3 x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Let T be a linear operator on the n dimensional vector space V and suppose that T has n distinct characteristic values. Establish that T is diagonalizable.	CO3	A
18.	The minimal polynomial divides the characteristic polynomial for T where T is a linear operator on a finite dimensional vector space *V*. Illustrate.	CO3	A
19.	Let W be an invariant subspace for T. The characteristic polynomial for the restriction operator T_W divides the characteristic polynomial for T. Moreover the minimal polynomial for T_W divides the minimal polynomial for T. Explain.	CO3	A
20.	For a finite dimensional vector space V over the field F and for a commuting family of triangulable linear operators on V illustrate that there exists an ordered basis for V such that every operator in the commuting family is represented by a triangular matrix in that basis.	CO3	A

(3 x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question

21.	(a)Let V be a vector space of all functions from R into R. Ve and V_o are even and odd functions from R into R respectively. Examine whether V_e and V_o are subspaces of V and $V_e + V_o = V$. (b)Illustrate that A and B are row equivalent if and only if they have the same row space, where A and B are m x n matrices over the field F.	CO1	A
22.	Let m and n be positive integers and let F be a field. Suppose W is a subspace of F^n and dim W ≤ m. Establish that there is precisely one m x n row reduced echelon matrix over F which has W as its row space.	CO1	A

(1 x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO4. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	(a)Given V is a finite dimensional vector space. Let $W_1, \ldots, W_k$ be subspaces of V and let W = $W_1 + \ldots + W_k$. Conclude that $W_1, \ldots, W_k$ are independent if and only if for each j, $2 \le j \le k$, we have $W_j \cap (W_1 + \ldots + W_{j-1}) = \{0\}$. (b) Suppose that E is a projection on V with range R and null space N. Deduce that $V = R \oplus N$.	CO4	An
24.	Explain Primary Decomposition Theorem for vector spaces.	CO4	An

(1 x 5= 5 weights)

SEMESTER I

CORE COURSE

MT1C02TM25 – Basic Topology

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze the fundamental concepts of topology, including topological spaces, bases, subbases, and subspaces. (An)

CO2: Apply the properties of closed sets, closures, neighbourhoods, and accumulation points in topological spaces to problem-solving scenarios. (A)

CO3: Analyze the concepts of connectedness, local connectedness, and path-connectedness in various topological spaces. (An)

CO4: Apply the hierarchy of separation axioms to develop solutions for complex topological problems, demonstrating their relationship with compactness and their implications in product and embedding theorems. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	2
CO2	2	1	1	1	2
CO3	3	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I (CO1) **(25 hours)**

Topological Spaces: Definition of a topological space – Examples of topological spaces-Bases and subbases – subspaces.

(Chapter 4; Sections 1, 2, 3, and 4 of the text)

Module II (CO2) **(20 hours)**

Basic concepts: Closed sets and Closures – Neighbourhoods, Interior and Accumulation points – Continuity and Related Concepts

(Chapter 5; Section 1;1. To 1.7, Section 2; 2.1 to 2.10 and 2.13, Section 3; 3.1 to 3.11, Theorem 3.2 condition 4 excluded)

Module III (CO3) **(20 hours)**

Spaces with special properties: - Smallness conditions on a space, Connectedness, Local connectedness and Paths

(Chapter 6: Section 1; 1.1 to 1.17`, Section 2; 2.1 to 2.15, sections 3;3.1 to 3.8)

Module IV (CO4) **(25 hours)**

Separation axioms: - Hierarchy of separation axioms, Compactness and Separation Axioms

Product and Coproducts: The Cartesian product of family of sets, product topology, productive properties, Embedding Lemma, Embedding theorem and Urysohn's Metrization Theorem.

(Chapter 7: Sections 1.1 to 1.17, Section 2;2.1 to 2.10)

(Relevant sections of Chapter 8 & 9 of Text 1)

Learning Resources:

Text Books:

K.D Joshi, Introduction to General Topology, Wiley Eastern Ltd, 1984

References:

1. Munkres J.R, Topology-A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Stephen Willard, General Topology, Addison-Wesley, 2004.
3. Dugundji, Topology, Universal Book Stall, New Delhi, 1989.
4. George F Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
5. J. Arthur Seebach, Lynn Arthur Steen, Counterexamples in Topology, Dover Publications, 1995.
6. George F. Simmons, Introduction to Topology and Modern Analysis, McGrawHill Book Company,1963

7. I.M. Singer &J.A. Thorpe, Lecture Notes on Elementary Topology & Geometry, Springer Verlag 2004

<u>Blueprint</u>

MT1C02TM25 – Basic Topology

Blueprint model BP 3

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO 1	CO 2	CO3	CO 4	CO2	CO3	CO1	CO4	
Module I 25 hrs	CO1	3	0	0	0	0	0	2	0	13
Module II 20 hrs	CO2	0	3	0	0	4	0	0	0	11
Module III 20 hrs	CO3	0	0	3	0	0	4	0	0	11
Module IV 25 hrs	CO4	0	0	0	3	0	0	0	2	13

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 3)

MT1C02TM25 – Basic Topology

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	There is no convergent sequence in a trivial space, Explain	CO1	A
2.	Analyze the convergence of sequences in a cofinite topology	CO1	An
3.	Establish that the intersection of semi-open interval topologies on $\mathbb{R}$ yields the usual topology on $\mathbb{R}$.	CO1	A

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Establish the continuity of a constant function at any point in its domain.	CO2	A
5.	Every Infinite subset of a co-finite space is dense in X. Explain.	CO2	A
6.	Establish that if X is a topological space and Y is a subspace of X, then a subset of Y is closed in Y if and only if it can be written as the intersection of Y with a closed set in X	CO2	A

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Use the definition of compactness to establish that the continuous image of a compact space is compact.	CO3	A
8.	Every second countable space is first countable.Explain	CO3	A
9.	Topological product of of any finite number of connected space is connected.Explain	CO3	A

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Tychonoff space is regular.Explain	CO4	A
11.	Construct a topological space that satisfies the T2 property but not the T3 property.	CO4	A
12.	Establish that if each coordinate space is T3 then the topological product has the corresponding property.	CO4	A

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO2. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Establish that for a subset A of a topological space X, $\bar{A} = A \cup A'$	CO2	A
14.	Let X be a space and $A \subset X$ then int A is the union of all open sets contained in A and also it is the largest open set contained in A, Explain	CO2	A

15.	Use the definition of closure to establish the characterization of a dense subset	CO2	A
16.	Apply the definitions of continuity to establish and illustrate the equivalent conditions for a function to be continuous.	CO2	A

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Establish that a subset of $\mathbb{R}$ is connected if and only if it is an interval, and support your reasoning with appropriate arguments.	CO3	A
18.	Articulate the statement of the Lebesgue Covering Lemma and establish its proof with appropriate justifications	CO3	A
19.	Apply the concept of local connectedness to determine whether every quotient space of a locally connected space remains locally connected, and provide a rigorous proof to support your conclusion.	CO3	A
20.	Examine the conditions under which the union of a collection of connected subsets of X with a common point remains connected, and explain the underlying reasoning with a proof.	CO3	An

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	a) Let X be a set and $\mathscr{B}$ a family of its subsets covering X. Establish the equivalence of the following statements: (1) There exists a topology on X with $\mathscr{B}$ as a base. (2) For any $B_1, B_2 \in \mathscr{B}$, $B_1 \cap B_2$ can be expressed as the union of some members of $\mathscr{B}$.	CO1	A

	(3) For any $B_1, B_2 \in \mathscr{B}$ and $x \in B_1 \cap B_2$, there exists $B_3 \in \mathscr{B}$ such that $x \in B_3$ and $B_3 \subset B_1 \cap B_2$. b)If a space is second countable then every open cover of it has a countable subcover, Explain		
22.	Use the definition of a topology to establish that the intersection of topologies on a set X is again a topology. Apply this result to demonstrate the existence of a unique smallest topology on X containing a given family of subsets	CO1	A

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO4. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Construct an example of a connected space that is not locally connected and explain why it satisfies these properties.Define a locally connected space and develop a proof showing that every quotient space of a locally connected space	CO4	A
24.	(a) Apply the concepts of separation axioms T_0, T_1, T_2, T_3, and T_4 to construct a hierarchy diagram.Explain with example. (b) Establish the hereditary nature of regularity in topological spaces	CO4	A

(1x 5= 5 weights)

SEMESTER I

<u>CORE COURSE</u>

MT1C03TM25 - Real Analysis

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze the concepts of functions of bounded variation and rectifiable curves, and examine their properties, including total variation and arc length. (An)

CO2: Apply the Riemann-Stieltjes integral to evaluate integrals, explore its properties, and examine its relationship with differentiation and vector-valued functions. (A)

CO3: Analyze the uniform convergence of sequences and series of functions and its impact on continuity, integration, and differentiation. (An)

CO4: Apply equicontinuous families of functions and utilize the Stone-Weierstrass theorem for function approximation, along with understanding power series, exponential, logarithmic and trigonometric series. (A)

<u>Mapping of Course Outcomes with Program Specific Outcomes</u>

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	2
CO2	2	2	1	1	2
CO3	3	2	1	1	2
CO4	2	2	1	1	2

Pre Requisites: Metric Spaces; Definition and examples, open and closed sets in metric space, compactness, Connectedness, Continuity, Uniform continuity, discontinuity, Derivatives and continuity, L'Hospital Rules, Mean-Value theorem, Derivatives of vector-valued functions. (Chapter 2,4,5 of Text 2)

Module I (CO1) **(20 hours)**

Functions of bounded variation and rectifiable curves: Introduction, properties of monotonic functions, functions of bounded variation, total variation, additive property of total variation, total variation on (a, x) as a functions of x, functions of bounded variation expressed

as the difference of increasing functions, continuous functions of bounded variation, curves and paths, rectifiable path and arc length, additive and continuity properties of arc length, equivalence of paths, change of parameter.
(Chapter 6, Section: 6.1 - 6.12. of Text 1)

Module II (CO2) **(20 hours)**
The Riemann-Stieltjes Integral: Definition and existence of the integral, properties of the integral, integration and differentiation, integration of vector valued functions.
(Chapter 6 - Section 6.1 to 6.25 of Text 2)

Module III (CO3) **(25 hours)**
Sequence and Series of Functions: Discussion of main problem, Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform convergence and Differentiation.
(Chapter 7 Section. 7.1 to 7.18 of Text 2)

Module IV (CO4) **(25 hours)**
Weierstrass Approximation &Some Special Functions: Equicontinuous families of functions, the Stone - Weierstrass theorem, Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field.
(Chapter 7 – Sections 7.19 to 7.27, Chapter 8 - Section 8.1 to 8.8 of Text 2)

Learning Resources:
Text Books:
Text 1: Tom Apostol, Mathematical Analysis (Second edition), Naros Publishing House.
Text 2: Walter Rudin, Principles of Mathematical Analysis (Third edition), McGraw Hill Book Company, International Editions.

References:
1. Robert G. Bartle Donald R. Sherbert, Introduction to Real Analysis, 4th Edition, JohnWiley and Sons, New York.
2. Gerald B. Folland, Real Analysis: Modern Techniques and Their Applications, 2nd Edition, Weily Interscience Publication, John Wiley and Sons, New York.
3. Royden H.L, Real Analysis, 2nd edition, Macmillan, New York.
4. Kenneth A. Ross, Elementary Analysis - The Theory of Calculus Second Edition, Springer International.
5. Shanti Narayan & M.D. Raisinghania, Elements of Real Analysis, 7th Edition, S. Chand Publishing, New Delhi

Blueprint

MT1C03TM25 – Real Analysis
Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I 20 hrs	CO1	3	0	0	0	0	0	2	0	13
Module II 25 hrs	CO2	0	3	0	0	0	0	0	2	13
Module III 20 hrs	CO3	0	0	3	0	4	0	0	0	11
Module IV 25 hrs	CO4	0	0	0	3	0	4	0	0	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

MT1C03TM25 -Real Analysis

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	If f is monotonic on [a,b], then f is of bounded variation. Discuss.	CO1	A
2.	Explain graph of a function and rectifiable paths.	CO1	A
3.	If f is of bounded variation on [a,b], then f is bounded on [a,b].	CO1	A

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Explain Riemann-Stieltjes integral of f with respect to $\propto$ over [a,b].	CO2	A
5.	If f is monotonic on [a,b] and if $\propto$ is continuous on [a,b]. Establish that $f \in \mathscr{R}(\propto)$	CO2	A
6.	State and prove integration by parts.	CO2	A

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Illustrate using an example that, limit process cannot be interchanged without affecting the result.	CO3	An
8.	Apply the definition of uniform convergence to check whether the function $f_n(x) = \frac{nx}{1+n^2x^2}$; $x \in [0, 1]$ converges uniformly or not.	CO3	A
9.	Examine that the sequence $\{f_n\}$ converges to f with respect to the metric of $\zeta(X)$ if and only if f_n converges to f uniformly on X.	CO3	A

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	If K is a compact metric space, if $f_n \in \zeta(X)$ for n = 1,2,3… and if $\{f_n\}$ converges uniformly on K, examine $\{f_n\}$ is equicontinuous on K.	CO4	A
11.	Apply Stone Weierstrass theorem to explain for every interval there is a sequence [-a,a] there is a sequence of real polynomials P_n such that $P_n(0) = 0$ and $\lim_{n\to\infty} P_n(x) = \|x\|$ uniformly on [-a,a].	CO4	A
12.	Examine whether every convergent sequence contains a uniformly convergent subsequence.	CO4	A

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO2. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Establish Cauchy Criterion for Uniform convergence.	CO3	An
14.	If $\{f_n\}$ is a sequence of continuous functions on E and if f_n converges to f uniformly on E. Examine that f is continuous on E.	CO3	A
15.	Analyse Weierstrass M-test.	CO3	An
16.	Let $\propto$ be monotonically increasing on [a,b] with $f_n \in R(\propto)$ on [a,b] for n = 1,2,3… and f_n converges to f uniformly on [a,b]. Establish that $f \in R(\propto)$ and $\int_a^b f d\propto = \lim_{n\to\infty} \int_a^b f_n d\propto$.	CO3	A

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Qn. No	Questions	CO	Level of Question
17.	Establish Stone- Weierstrass theorem.	CO4	A
18.	If $\{f_n\}$ is a pointwise bounded sequence of complex functions on a countable set E, then interpret whether $\{f_n\}$ has a subsequence $\{f_{n,k}\}$ such that $\{f_{n,k}(x)\}$ converges for every $x \in E$.	CO4	A
19.	If K is a compact metric space, if $\{f_n\} \in \zeta(K)$ for n = 1,2,3… and if $\{f_n\}$ converges uniformly on K, then examine $\{f_n\}$ is equicontinuous on K.	CO4	A

20.	Suppose $\sum c_n$ converges and $f(x) = \sum_{n=0}^{\infty} c_n x^n$; $-1 < x < 1$. Examine $\lim_{x \to 1} f(x) = \sum_{n=0}^{\infty} c_n$.	CO4	A

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	a) Use the definition of total variation to establish that, total variation of a constant function is zero. b) Explain additive property of total variation	CO1	A
22.	Explain characterization of rectifiable curves	CO1	An

(1x 5= 5 weight)

Part C2. Answer any 1 question from the bunch for CO4. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Suppose $c_n \geq 0$ for 1,2,3…., $\sum c_n$ converges, $\{s_n\}$ is a sequence of distinct points in (a,b) and $\alpha(x) = \sum_{n=1}^{\infty} c_n I(x - s_n)$. Let f be continuous on [a,b], establish $\int_a^b f d\alpha = \sum_{n=1}^{\infty} c_n f(s_n)$	CO2	A
24.	Assume α increases monotonically and $\alpha' \in R$ on [a,b]. Let f be a bounded real function on[a,b]. Establish $f \in R(\propto)$ if and only if $f \propto' \in R$, also $\int_a^b f d\alpha = \int_a^b f(x) \propto'(x) dx$.	CO2	A

(1x 5= 5 weights)

SEMESTER I

CORE COURSE

MT1C04TM25 – Abstract Algebra

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the concepts of direct products, Abelian groups, and group actions to solve problems in group theory. (A)

CO2: Analyze group structures using isomorphism and Sylow theorems to classify subgroups and solve problems in finite group theory. (An)

C03: Develop an understanding of Fermat's and Euler's theorems, construct the field of quotients of an integral domain, and apply polynomial ring concepts to factorization over a field. (A)

CO4: Analyze the properties of homomorphisms and factor rings, and examine the role of prime and maximal ideals in ring theory. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	3	1	1	1	2
CO3	2	1	1	1	2
CO4	3	1	1	1	2

Module I (CO1) **(25 hours)**

Direct products, Homomorphisms and factor groups: Direct products and finitely generated Abelian groups, Homomorphisms, Factor groups, Group action on set, Applications of G- sets to counting.

(Part II – Sections 11, Part III - 13 (proofs excluded), 14, 16 & 17)

Module II: (CO2) **(25 hours)**

Advanced Group Theory: Isomorphism theorems, Sylow theorems, Applications of the Sylow theory.

(Part VII - Sections 34, 36 & 37)

Module III:(CO3) **(20 hours)**

Rings and Fields : Fermat's and Euler's Theorems, The field of quotients of an integral domain, Rings of polynomials, Factorization of polynomials over a field.

(Part IV – Sections 20, 21, 22 & 23)

Module IV:(CO4) **(20 hours)**

Ideals and Factor Rings : Homomorphisms and factor rings, Prime and Maximal Ideals.

(Part V – Sections - 26 & 27)

Learning Resources:

Text Books:

John B. Farleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

References:

1. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.\
2. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. M. Artin, Algebra, Prentice -Hall of India, 1991.
4. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, 2004.
5. Klaus Jonich. Linear Algebra, Springer Verlag.
6. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
7. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
8. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
9. Roger A. Horn, Charles R. Johnson, Matrix Analysis, Second Edition, Cambridge University press.
10. Thomas W. Hungerfor, Algebra (Graduate texts in Mathematics), Springer

11. N. Jacobson, Basic Algebra Vol. I, Hindustan Publishing Corporation
12. P.B. Bhattacharya, S.K. Jain, S.R. Nagapaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, Indian Edition, 1997.

Blueprint

MT1C04TM25 – Abstract Algebra

Blueprint model BP 3

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I 20 hrs	CO1	3	0	0	0	0	0	2	0	13
Module II 25 hrs	CO2	0	3	0	0	4	0	0	0	13
Module III 20 hrs	CO3	0	0	3	0	0	4	0	0	11
Module IV 25 hrs	CO4	0	0	0	3	0	4	0	2	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 3)

MT1C04TM25 – Abstract Algebra

Time: Three hours **Maximum Weight: 30**

Part A

Part A1.Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Illustrate with examples a) Decomposable Group b) Indecomposable Group.	CO1	A
2.	Compute the number of orbits in {1,2,3,4,5,6,7,8} under the subgroup of S8 generated by (1,3) and (2,4,7)	CO1	A
3.	Establish that every group of order divisible by 6 contains a cyclic group of order 6	CO1	A

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Explain 3rd Isomorphism theorem. Illustrate the theorem with the help of an example.	CO2	An
5.	Establish that no group of order 20 is simple.	CO2	An
6.	Compute all the Sylow-p-subgroups of S3 where p = 2, 3	CO2	A

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	a) Explain Little Theorem of Fermat. b) Find the remainder of 8^{103} when divided by 13.	CO3	A

8.	If $a \in Z$ then establish that $a^p \equiv a (mod\ p)$ for any prime p.	CO3	A
9.	Illustrate that R[x] of all polynomials of an indeterminate x with coefficients in a ring R is ring under polynomial addition and multiplication.	CO3	A

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Establish that the quaternions H form a strictly skew field under addition and multiplication	CO4	A
11.	Explain the theorem which shows subrings correspond to subrings and rings with unity corresponds to rings with unity under a ring homomorphism	CO4	An
12.	a)Illustrate with an example which shows that If R is not even an integral domain, that is, if R has zero divisors, it is still possible for R/N to be a field. b) Establish that, If R is a ring with unity, and N is an ideal of R containing a unit, then N = R.	CO4	An

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO2. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Deduce the class equation of a group G	CO2	An
14.	Establish that every group of prime power order is solvable.	CO2	A
15.	Explain Cauchy's Theorem	CO2	A
16.	For a prime number p, every group G of order P^2 is abelian. Illustrate	CO2	A

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Let p be a prime ≥ 3. Use Wilson's theorem to compute the remainder of (p-2)! modulo p.	CO3	A
18.	Establish that R[x] of all polynomials of an indeterminate x with coefficients in a ring R is ring under polynomial addition and multiplication.	CO3	A
19.	A non zero polynomial f(x)∈ $F[x]$of degree n can have at most n zeros in the Field F.	CO3	A
20.	Illustrate $f(x) = x^3 + 3x + 2$ in $Z_5[x]$ is irreducible over Z_5 b)Establish that f(x)∈ $F[x]$ and let f(x) be of degree 2 or 3, then f(x) is irreducible over F if and only if it has a zero in F	CO3	A

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	a)Explain fundamental theorem of homomorphism for groups.	CO1	A
22.	a)Explain Burnside's Formula b) Establish that if If G is a finite group and X is a finite G set, then prove that the number of orbits in X under $G = \frac{1}{\vert G\vert}\sum_{g\in G}\left\vert X_g\right\vert$	CO1	U, A

(1x 5= 5 weight)

Part C2. Answer any 1 question from the bunch for CO4. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	a) Let R be a commutative ring with unity, then M is a maximal ideal of R iff R/M is a field. Explain b) Illustrate the above theorem with the help of an example.	CO4	An
24.	Explain Fundamental Theorem on Homomorphism for Rings	CO4	A

(1x 5= 5 weights)

SEMESTER I

CORE COURSE

MT1C05TM25 – Graph Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze fundamental graph structures, including subgraphs, degrees of vertices, paths, connectedness, and automorphisms, to interpret their properties and relationships. (An)

CO2: Apply connectivity concepts, vertex and edge cuts, blocks, and spanning trees to construct and verify graph structures, utilizing Cayley's formula. (A)

CO3: Apply advanced graph-theoretic techniques to solve problems related to independent sets, matchings, Eulerian and Hamiltonian graphs, and graph colorings. (A)

CO4: Apply planarity concepts and edge colorings to model and solve complex graph structure problems. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	2
CO2	2	1	1	1	2
CO3	2	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I: (CO1) **(20 hours)**

Basic Results: Introduction, Basic concepts. Sub graphs. Degrees of vertices. Paths and Connectedness, Automorphism of a simple graph, line graphs and operations on graphs.
Directed Graphs: Introduction, basic concepts and tournaments.
(Chapter 1 Sections 1.1 – 1.7 (Up to 1.7.3 including) and 1.8
(Chapter 2 Sections 2.1, 2.2, 2.3)

Module II: (CO2) **(25 hours)**

Connectivity: Introduction, Vertex cuts and edge cuts, connectivity and edge connectivity, blocks, Cyclical edge Connectivity of a graph.

Trees: Introduction, Definition, characterization and simple properties, centres and centroids, counting the number of spanning trees, Cayley's formula.

(Chapter 3 Sections 3.1 - 3.5)

(Chapter 4 Sections 4.1, 4.2, 4.3, 4.4 (Up to 4.4.3 including) and 4.5)

Module III: (CO3) **(20 hours)**

Independent Sets and Matchings: Introduction, Vertex-Independent Sets and Vertex Coverings, Edge-Independent Sets, Matchings and Factors, Matchings in Bipartite Graphs

Eulerian and Hamiltonian Graphs: Introduction, Eulereian graphs, Hamiltonian Graphs, Hamiltonian's "Around the world" game.

(Chapter 5 Sections 5.1-5.5 Up to 5.5.4 including)

(Chapter 6 Sections 6.1, 6.2 and 6.3)

Module IV: (CO4) **(25 hours)**

Graph Colorings: Introduction, Vertex Colorings, Applications of Graph Coloring, Critical Graphs, Brooks' Theorem,Edge colorings of graphs

Planarity: Introduction, Planar and Nonplanar Graphs, Euler Formula and Its Consequences, K5 and K 3,3 are Nonplanar Graphs, Dual of a Plane Graph, The Four-Color Theorem and the Heawood Five-Color Theorem.

(Chapter 7 Sections 7.1, 7.2 and 7.3(Up to 7.3.1 including), 7.4)

(Chapter 8 Sections 8.1, 8.2, 8.3, 8.4, 8.5 and 8.6)

Text : R. Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Second edition Springer.

References:

1. John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.
2. Douglas B West, Introduction to Graph Theory, Prentice Hall of India.
3. Sheldon Axler, Linear algebra done right, Second edition, Springer.
4. J. A. Bondy, U.S.R. Murty: Graph Theory; Springer; 2000.
5. S. M. Cioaba and M.R. Murty: A First Course in Graph Theory and Combinatorics; Hindustan Book Agency; 2009.
6. R. Diestel: Graph Theory (4th Edn.); Springer-Verlag; 2010 [5] J. L. Gross: Graph theory and its applications (2nd edn.); Chapman & Hall/CRC; 2005.
7. F. Harary: Graph Theory; Narosa Pub. House, New Delhi; 1992.
8. Narsingh Deo: Graph Theory with Applications to Engineering & Computer Science; Dover Publications Inc; New York
9. W. T. Tutte: Graph Theory; Cambridge University Press; 2001

10. D. B. West: Introduction to graph theory; Prentice Hall; 2000.
11. R. J. Wilson: Introduction to Graph Theory; Longman Scientific and Technical Essex (co-published with John Wiley and sons NY); 1985.

Blueprint

MT1C05TM25 – Graph Theory

Blueprint model BP 3

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	PartC 2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO2	CO3	CO1	CO4	
Module I 20 hrs	CO1	3	0	0	0	0	0	2	0	13
Module II 25 hrs	CO2	0	3	0	0	4	0	0	0	11
Module III 20 hrs	CO3	0	0	3	0	0	4	0	0	11
Module IV 25 hrs	CO4	0	0	0	3	0	0	0	2	13

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 3)

MT1C05TM25 – Graph Theory

Time: Three hours **Maximum Weight: 30**

Part A

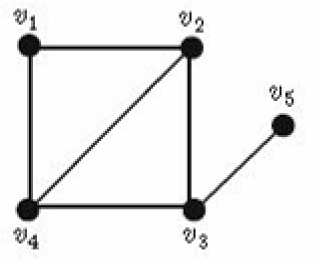
Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Consider a graph G with n vertices and m edges, where each vertex has a degree of either k or k+1. Analyze the degree distribution of the vertices and deduce an expression for the number of vertices with degree k in terms of n and m.	CO1	An
2.	Establish that if G is a self-complementary graph of order n, then $n \equiv 0 \pmod 4$ or $n \equiv 1 \pmod 4$ using appropriate graph-theoretic properties.	CO1	A
3.	Establish that if G and H are isomorphic graphs, then each pair of corresponding vertices has the same degree by applying the concept of graph isomorphism.	CO1	A

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Establish that a simple connected graph G with n(G)=m(G) is unicyclic by demonstrating the relationship between the number of vertices and edges in the graph's structure.	CO2	A
5.	Apply the concept of trees to determine that a tree with at least two vertices contains at least two pendant vertices, and illustrate the reasoning.	CO2	A

6.	Compute τ(G) for the given graph and illustrate the steps involved 	CO2	A

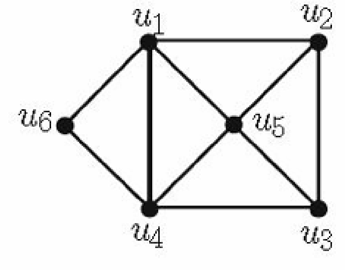
(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Establish that the Hamiltonian graph is 2-connected.	CO3	A
8.	Establish that if G (X, Y) is a bipartite Hamiltonian graph, then |X|=|Y| by constructing a suitable proof.	CO3	A
9.	Establish that an edge e of a connected graph G with at least 3 vertices is a cut edge of G if and only if there exist vertices u and v of G such that e is on every u-v path	CO3	A

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Construct the dual of the given graph 	CO4	A

11.	Determine and illustrate the relationship between $\chi(G)=2$ and bipartite graphs with at least one edge using graph coloring principles.	CO4	A
12.	Establish the presence of a C_4 in every simple bipartite cubic planar graph by applying appropriate graph-theoretic concepts	CO4	A

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO2. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Establish that every tree has a center consisting of either a single vertex or two adjacent vertices.	CO2	A
14.	Explain Whitney's Theorem and construct its proof with appropriate reasoning.	CO2	A
15.	Establish that in a connected graph G, any two longest cycles have at least two vertices in common.	CO2	A
16.	Establish that a connected simple graph is 3- edge connected if and only if every edge of G is the exact intersection of the edge sets of two cycles of G.	CO2	A

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Establish the Hamiltonian nature of a simple graph G with $n \geq 3$ vertices by modifying it through the addition of an edge between any pair of non-adjacent vertices u and v where $d(u) + d(v) \geq n$	CO3	A
18.	Establish the Hamiltonian connectivity of a simple graph G with $n \geq 3$ vertices by modifying it under the condition that	CO3	A

	for every pair of non-adjacent vertices u and v, $d(u) + d(v) \geq n+1$		
19.	Explain Ore's theorem and construct its proof with appropriate reasoning.	CO3	A
20.	Determine the relationship between the independence number and the number of vertices in a graph, and establish an inequality connecting them.	CO3	A

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	a) Differentiate bipartite graphs from other graph types and classify their key characteristics. b) Analyze the structure of regular bipartite graphs and deduce why $\|X\|=\|Y\|$. c) Investigate the relationship between bipartiteness and cycle structure, and conclude why a graph is bipartite if and only if it contains no odd cycles.	CO1	An
22.	a) Differentiate the line graph of G from G itself and determine the number of vertices and edges in the line graph. b) Examine the conditions under which the line graph of G forms a path and deduce that G itself must also be a path. c) Compare the structure of two isomorphic simple graphs G_1 and G_2 and justify that their corresponding line graphs $L(G_1)$ and $L(G_2)$ are also isomorphic.	CO1	An

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO4. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	(a)Establish the non-planarity of K_5 and $K_{3,3}$ (b)Employ graph coloring techniques to articulate and demonstrate the Heawood Five-Color Theorem.	CO4	A

24.	(a) Employ graph coloring techniques to demonstrate that every planar graph is 6-vertex colorable. (b) Apply the concept of graph coloring to establish that every planar graph is 5-vertex colorable.	CO4	A

(1x 5= 5 weights)

SEMESTER II

SEMESTER II

CORE COURSE

MT2C06TM25 – Complex Analysis

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Explain the fundamental concepts of complex analysis, including the Riemann Sphere, stereographic projections, power series, conformal mappings, and linear transformations. (An)
CO2: Apply Cauchy integral theorem and formula to evaluate complex integrals, utilizing concepts like line integrals, Cauchy's theorem in various regions, and the index of a point with respect to a closed curve. (A)
CO3: Interpret the fundamental theorems in Complex Analysis, such as Morera's Theorem, Liouville's Theorem, and Cauchy's Estimate, to solve problems involving analyticity, singularities, and maximum principles. (A)
CO4: Solve complex analysis problems using the calculus of residues, including evaluating definite integrals and applying the residue theorem and the argument principle in multiply connected regions. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	2
CO2	2	1	1	1	2
CO3	2	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I (CO1) **(25 hours)**

The spherical representation of complex numbers: Riemann Sphere, Stereographic projection, Distance between the stereographic projections.
Elementary Theory of power series: Abel's Theorem on convergence of the power series, Hadamard's formula, Abel's limit Theorem.

Conformality: Arcs and closed curves, Analytic functions in regions, Conformal mappings.
Linear transformations: Linear Group, The cross ratio.
(Chapter – 1: Section 2.4, Chapter – 2: Sections.2.1 to 2.5, Chapter – 3: Sections 2.1 to 2.3 and 3.1 and 3.2 of the text.)

Module II (CO2) (20 hours)

Fundamental theorems on complex integration: line integrals, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk, Cauchy's integral formula: the index of a point with respect to a closed curve, the integral formula.
(Chapter- 4: Sections 1, 2.1 and 2.2 of the text.)

Module III (CO3) (20 hours)

Higher derivatives: Morera's Theorem, Liouville's Theorem, Fundamental Theorem, Cauchy's estimate, Local properties of analytical functions: removable singularities, Taylor's theorem, zeroes and poles, Weierstrass Theorem on essential singularity, the local mapping, the maximum principle, Schwarz lemma.
(Chapter-4: sections 2.3 and 3.1 to 3.4 of the text.)

Module IV (CO4) (25 hours)
The general form of Cauchy's theorem: chains and cycles, simple connectivity, homology, general statement of Cauchy's theorem, proof of Cauchy's theorem, locally exact differentials, multiply connected regions. Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals.
(Chapter-4: Sections 4 and 5 of the text.)

Learning Resources:

Text Book:

Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

References:

1.Chaudhary. B, The elements of Complex Analysis, Wiley Eastern, 1973
2.Cartan. H (1973), Elementary theory of Analytic functions of one or several variables, Addison Wesley.
3. Conway. J.B, Functions of one Complex variable, Narosa publishing.
4. Lang. S, Complex Analysis, Springer.
5. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990 6. T.W. Gamelin: Complex Analysis; Springer-Verlag, NY Inc.; 2001.

6. T.O. Moore and E.H. Hadlock: Complex Analysis, Series in Pure Mathematics-Vol. 9; World Scientific; 1991
7. L. Pennisi: Elements of Complex Variables (2nd Edn.); Holf, Rinehart & Winston 1976
8. H. Sliverman: Complex Variables; Houghton Mifflin Co. Boston; 1975.
9. R. Remmert: Theory of Complex Functions; UTM, Springer-Verlag, NY; 1991
10. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw - Hill

SEMESTER II

CORE COURSE

MT2C07TM25 – Functional Analysis

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the fundamental concepts of vector spaces, normed spaces, and Banach spaces and apply them to advanced problems in functional analysis. (A)

CO2: Apply the properties of linear operators, linear functionals and Hilbert spaces to solve mathematical problems. (A)

CO3: Analyze orthonormal sets, direct sums, and adjoint operators in Hilbert spaces.(An)

CO4: Analyze key theorems such as Hahn-Banach, uniform boundedness, and category theorem in functional analysis. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	2	2
CO2	2	1	1	2	2
CO3	3	1	1	2	2
CO4	2	1	1	2	2

Syllabus Content

Module I (CO1) **(25 hours)**

Vector Space, normed space. Banach space, further properties of normed spaces, finite dimensional normed spaces and subspaces, compactness and finite dimension, linear Operators, bounded and continuous linear operators.
(Chapter 2 - Sections 2.1 – 2.7 of the text)

Module II (CO2) **(20 hours)**

Linear functionals, linear operators and functionals on finite dimensional spaces, normed spaces of operators. dual space, inner product space. Hilbert space, further properties of inner product space.

(Chapter 2- Section 2.8 to 2.10, chapter 3- Sections 3.1 to 3.2 of the text, excluding section 3.2 3)

Module III (CO3) **(25 hours)**

Orthogonal complements and direct sums, orthonormal sets and sequences, series related to orthonormal sequences and sets, total orthonormal sets and sequences. Representation of functionals on Hilbert spaces, Hilbert adjoint operators, Self adjoint, unitary and normal operators.

(Chapter 3 - Sections 3.3 to 3.6 excluding section 3.5, 3.8 to 3.10 of the text)

Module IV (CO4) **(20 hours)**

Zorn's lemma, Hahn- Banach theorem for real vector space (statement only), Hahn- Banach theorem for complex vector spaces and normed spaces, adjoint operators, reflexive spaces, category theorem (Statement only), uniform boundedness theorem

(Chapter 4 – Sections 4.1 to 4.3, 4.5 to 4.7 of the text)

Learning Resources:

Text Book:

Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York.

References:

1. Balmohan V. Limaye, Functional Analysis, Revised Second Edition, New Age International Publishers, 1996 (Reprint 2013)
2. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York 1963.
3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi: 1989. 3. Somasundaram. D, Functional Analysis, S. Viswanathan Pvt. Ltd, Madras, 1994
4. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd (1996)
5. M Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008, Walter Rudin, Functional Analysis, TMH Edition, 1974.

SEMESTER II

CORE COURSE

MT2C08TM25 – Field Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Develop the concepts of extension fields and distinguish various types of extensions. (A)

CO2: Analyze unique factorization domains and Euclidean domains, and examine Gaussian integers and multiplicative norms in ring theory. (An)

CO3: Analyze field automorphisms, isomorphism extension theorem, and examine splitting fields in field theory (An)

CO4: Analyze field structures applying the concepts of separable extensions and Galois theory and illustrate Galois theory through examples. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	3	1	1	1	2
CO3	3	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I (CO1) **(20 hours)**

Extension Fields: Introduction to extension fields, algebraic extensions, Geometric Constructions, Finite fields.

(Part VI – Section 29, 31 – 31.1 to 31.18, 32, 33 of the text)

Module II (CO2) **(20 hours)**

Factorization: Unique factorization domains, Euclidean domains. Gaussian integers and multiplicative norms.

(Part IX – Sections 45,46 & 47 of the text)

Module III (CO3) **(25 hours)**

Automorphisms: Automorphism of fields, the isomorphism extension theorem, Splitting fields.

(Part X – Sections 48 & 49, 50 of the text)

Module IV (CO4) **(25 hours)**

Galois Theory: Separable extensions, Galois Theory, Illustrations of Galois Theory, Cyclotomic Extensions.

(Part X - Sections 51, 53, 54, 55 - 55.1 to 55.6 of the text)

- The topics "Geometric Constructions in Finite Fields" (Module 1) and "Cyclotomic Extensions" (Module IV) are given as an assignment. As part of the assignment, students are required to maintain an assignment book.

Learning Resources:

Text Books:

John B. Farleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

References:

1. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.
2. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. M. Artin, Algebra, Prentice -Hall of India, 1991.
4. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, 2004.
5. Klaus Jonich. Linear Algebra, Springer Verlag.
6. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
7. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
8. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
9. Roger A. Horn, Charles R. Johnson, Matrix Analysis, Second Edition, Cambridge University press.
10. Thomas W. Hungerfor, Algebra (Graduate texts in Mathematics), Springer
11. N. Jacobson, Basic Algebra Vol. I, Hindustan Publishing Corporation
12. P.B. Bhattacharya, S.K. Jain, S.R. Nagapaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, Indian Edition, 1997.

SEMESTER II

CORE COURSE

MT2C09TM25 – Numerical Analysis with Python

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply fundamental mathematical operations, symbolic computations, and equation-solving techniques using computational tools to interpret mathematical expressions. (A)

CO2: Develop programs to compute limits, derivatives, and integrals of functions and determine areas under curves. (A)

CO3: Apply interpolation techniques and root-finding algorithms to compute numerical solutions of equations. (A)

CO4: Analyze systems of equations by solving them using Gaussian elimination and LU Decomposition methods and evaluate definite integrals through numerical integration techniques. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	2
CO2	2	2	3	2	2
CO3	2	2	3	2	2
CO4	2	2	2	2	2

Syllabus Content

Module I (CO1) **(20 hours)**

Introduction to Python: General Information, Core Python, calculations and variables, strings, , If and else statements, loops, functions and modules, built in functions, complex numbers, working with lists and tuples, creating graphs with Matplotlib, plotting with formulas.
(Chapters 2, 3, 4, 5, 6, 7, 8 and 9 of text 1, Chapters 1 and 2 from text 2)

Module II (CO2) **(20 hours)**

Algebra and Symbolic Math with SymPy: Defining Symbols and Symbolic Operations, Working with Expressions, Solving Equations and Plotting Using SymPy, problems on factor finder, summing a series and solving single variable inequalities
(Chapter 4 - from text 2)
Solving Calculus Problems: Finding the limit of functions, finding the derivative of functions, higher-order derivatives and finding the maxima and minima and finding the integrals of functions are to be done In the section programming challenges, the following problems - verify the continuity of a function at a point, area between two curves and finding the length of a curve.
(Chapter 7 from text 2)

Module III (CO3) **(25 hours)**

Interpolation and Curve Fitting: Introduction, Polynomial Interpolation, Lagrange's Method, Newton's Method and Limitations of Polynomial Interpolation (Neville's Method omitted).

(Chapter 3, sections 3.1, 3.2 from Text 3,)
Roots of Equations: Introduction, Method of Bisection, Newton-Raphson Method.
(Chapter 4, sections 4.1, 4.3, 4.5 from Text 3,)

Module IV(CO4) **(25 hours)**

Systems of Linear Algebraic Equations: Introduction, Gauss Elimination Method (excluding Multiple Sets of Equations), LU Decomposition Methods (Doolittle's Decomposition Method only)
(Chapter 2, sections 2.2, 2.3, from Text 3.)
Numerical Integration: Introduction, Newton-Cotes Formulas, Trapezoidal rule, Simpson's rule and Simpson's 3/8 rule.
(Chapter 6, sections 6.1, 6.2 from Text 3.)

- As part of the assignment, students are required to maintain a record book. At least 15 programmes should be included in this record book.
- Internal assessment examinations should be conducted as practical lab examinations by the faculty handling the paper.
- End semester examination should focus on questions including concepts from theory and programming. However, more importance should be given to theory in the end semester examinations as internal examinations will be giving more focus on programming sessions.

Learning Resources:

Text Books:

Text 1: Jason R Brigs, Python for kids – a playful introduction to programming, No Starch Press

Text 2: Amit Saha, Doing Math with Python, No Starch Press, 2015.

Text 3: JaanKiusalaas, Numerical Methods in Engineering with Python3, Cambridge University Press.

References:

1. Hans Petter Langtangen, A primer on scientific programming with python, 3rd edition, Springer
2. Vernon L. Ceder, The Quick Python Book, Second Edition, Manning.
3. S. D. Conte and Carl de Boor, Elementary Numerical Analysis – An algorithmic approach, Third Edition, McGraw-Hill Book Company.
4. S.S. Sastry, Introductory Methods of Numerical Analysis, Fifth Edition, PHI.
5. Swaroop C H, A Byte of Python,2003.
6. E Balagurusamy ,Numerical Methods, Tata McGraw-Hill Publishing Company Limited, New Delhi.
7. Ajith Kumar B.P., Python for Education.
8. Eric Matthes, Python Crash Course, A Hands-On, Project - Based Introduction to Programming, 2nd Edition,
9. Allen B. Downey, Think Python, 2nd Edition.
10. Applied Numerical Methods with Python for Engineers and Scientists,Steven C. Chapra.
11. NumPy Reference Release 1.12.0, Written by the NumPy community. (available for free download at https://docs.scipy.org/doc/numpy-dev/numpy-ref.pdf)

SEMESTER II

CORE COURSE

MT2C10TM25 – Research Methodology

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze different research designs and determine the appropriate methodology for a given research problem. (An)

CO2: Evaluate mathematical writing for clarity, effectiveness, and adherence to scientific language standards. (An)

CO3: Evaluate the effectiveness of different mathematical models in solving practical problems, and choose the most appropriate model based on given data. (An)

CO4: Prepare a well-organized document using proper typesetting techniques, mathematical environments, and customized commands for efficient writing and formatting. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	2	1	1	1	2
CO3	2	2	2	1	2
CO4	2	1	3	1	2

Syllabus Content

Module I (CO1) **(25 hours)**

Introduction: Meaning of Research, Objectives of Research, Types of Research, Significance of Research, Defining the Research Problem, Identification, Selection of Research problem, Formulation of research objectives, Research design, Quantitative and qualitative methodology, importance of literature review- primary and secondary sources, reviews, monographs, research database, web sources, identifying gap areas from the literature and research database, surveying synthesis, Interpretation.
(Relevant sections from chapters 1, 2, 3 of text 1, chapters 2,3 of text 2)

Module II (CO2) **(25 hours)**

Mathematical research methodology: Introducing mathematics Journals, reading a Journal article, Ethics in Research and publications, Mathematics writing skills - Standard Notations and Symbols, Using Symbols and Words, organizing a paper, Defining variables, Symbols and notations, Different Citation Styles, Tools for checking Grammar and Plagiarism, IPR, patents/Trademarks and Copyrights, Procedure to apply Patents/Trademarks and Copyrights, The Patent/Trademarks Agent, H-index, impact factor, Immediacy index, acknowledgement and its index, copyrights, Bibliography, referencing and footnotes.
(relevant portions from text 3)

Module III (CO3) **(20 hours)**

Mathematical modelling: The technique of Mathematical Modelling, Classification of Mathematical Models, Some Characteristics of Mathematical Models, Modelling through Differential Equations, Linear Growth and Decay Models, Non-linear Growth and Decay Models, Mathematical Modelling through graphs.
(relevant portions from text 4)

Module IV(CO4) **(25 hours)**

LaTeX typesetting: Introduction to LaTeX Documentation setting, Standard document classes, Bibtex, standard environments, Macros, Table of contents, Bibliography styles, tables, Pstricks, Multiline math displays, Beamer.
(relevant portions from text 5 and 6)

Learning Resources:

Text Book:

1.C. R. Kothari and G Garg, Research methodology methods and techniques, 4 th ed., New Age International Publishers, New Delhi, 2019.
2. J W Creswell, Research Design, Sage South Asia Edition.
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, An introduction to Research Methodology, RBSA Publishers, U.K., 2002
4. J N Kapur – Mathematical Modelling – 2nd Edition (2021)
5. George Gratzer ¨ More Math Into LATEX 4th Edition, Springer, 2007.
6.. Donald. E. Knuth, Computers & Typesetting, Addison-Wesley, (1986).

References:

1. E. B. Wilson, An introduction to scientific research, Reprint, Courier Corporation, 2012.R. Ahuja, Research Methods, Rawat Publications, 2001.
2. G. L. Jain, Research Methodology, Mangal Deep Publications, 2003.

3. B. C. Nakra and K. K. Chaudhry, Instrumentation, measurement and analysis, TMH Education,2003.
4. L. Radhakrishnan, Write Mathematics Right: Principles of Professional Presentation, Exemplified with Humor and Thrills, Alpha Science International, Limited, 2013.
5. G. Polya, How to solve it: a new aspect of mathematical method. Princeton, N.J.: Princeton University Press, 1957.
6. R. Hamming, You and your research, available at https://www.cs.virginia.edu/~robins/YouAndYourResearch.html
7. T. Tao, Advice on writing papers, https://terrytao.wordpress.com/advice-on-writing-papers/
8. Intellectual property rights- laws and practice, The Institute of Company Secretaries of India, New Delhi, 2018.
9. https:// ipindia.gov.in (Official website of Intellectual Property India), 2024.
10. S. Shukla, J.P. George, K. Tiwari and J.V. Kureethara (2022). Intellectual Property Right - Copyright. In: Data Ethics and Challenges. SpringerBriefs in Applied Sciences and Technology (). Springer, Singapore. https://doi.org/10.1007/978-981-19-0752-4_5
11. Harold Rabinowitz, Suzanne Vogel: The manual of scientific style, Academic press(2009).
12. David F. Griffiths, Desmond J.Higham: Learning LATEX. Society for Industrial and Applied Mathematics, Philadelphia (1997).
13. Laslie Lamport: LATEX, Addison Wesley Publications Company (1994).
14. S. G. Krantz, A Primer of Mathematical Writing, Second Edition, American Mathematical Society, 2017.

SEMESTER III

SEMESTER III

CORE COURSE

MT3C11TM25– Spectral Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze the concepts of strong and weak convergence, operator sequences, and fundamental theorems in functional analysis, including the Open Mapping and Banach Fixed Point theorems. (An)

CO2: Analyze the properties of bounded linear operators and Banach algebras in normed spaces applying spectral theory. (A)

CO3: Analyze the spectral and compact properties of linear operators in normed spaces, including their further spectral characteristics. (An)

CO4: Apply the spectral properties of bounded self-adjoint and projection operators, including their applications in functional analysis. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	2
CO2	2	1	1	2	2
CO3	3	1	1	2	2
CO4	2	1	1	2	2

Syllabus Content

Module I (CO 1) **(25 hours)**

Strong and weak convergence, convergence of sequence of operators and functionals, open mapping theorem, closed linear operators, closed graph theorem, Banach fixed point theorem (Chapter 4 - Sections 4.8, 4.9, 4.12 & 4.13 - Chapter 5 – Section 5.1 of the text)

Module II (CO2) **(25 hours)**
Spectral theory in finite dimensional normed space, basic concepts, spectral properties of bounded linear operators, further properties of resolvant and spectrum, use of complex analysis in spectral theory, Banach algebras, further properties of Banach algebras.
(Chapter 7 - Sections 71. to 7.7 of the text)

Module III (CO3) **(20 hours)**
Compact linear operators on normed spaces, further properties of compact linear operators, spectral properties of compact linear operators on normed spaces, further spectral properties of compact linear operators.
(Chapter 8 - Sections 8.1 to 8.4 of the text)

Module IV (CO4) **(20 hours)**
Spectral properties of bounded self adjoint linear operators, further spectral properties of bounded self adjoint linear operators, positive operators, projection operators, further properties of projections.
(Chapter 9 - Sections 9.1, 9.2, 9.3, 9.5, 9.6 of the text)

Learning Resources:

Text Book:
Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

References:

1. Balmohan V. Limaye, Functional Analysis, Revised Second Edition, New Age International Publishers, 1996 (Reprint 2013)
2. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York 1963
3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi: 1989
4. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt Ltd, Madras, 1994
5. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd, Meerut: 1995-96
6. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008

SEMESTER III

CORE COURSE

MT3C12TM25 – Measure Theory and Integration

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the definition of Lebesgue outer measure to compute the measure of given sets (A)

CO2: Compute the Lebesgue integral of a non-negative measurable function and extend the process to general measurable functions. (A)

CO3: Analyze the properties of general measure spaces. (An)

CO4: Apply the concepts of integration in general measure spaces to compute the integral of non-negative measurable functions. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	2	1	1	1	2
CO3	3	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I (CO1) **(25 hours)**

Lebesgue Measure: Introduction, Lebesgue outer measure, the σ algebra of Lebesgue measurable sets, Outer and inner approximation of Lebesgue measurable sets, Countable additivity, continuity and Borel, Cantelli Lemma, Non measurable sets, The Cantor set and Cantor Lebesgue function.
(Chapter 2-Sections 2.1 to 2.7)

Module II (CO2) **(25 hours)**

Lebesgue Measurable Functions and Lebesgue Integration: Sums, products and compositions, Sequential pointwise limits and simple approximation, The Riemann Integral, The Lebesgue integral of a bounded measurable function over a set of finite measure, The Lebesgue integral of a measurable non negative function, The general Lebesgue integral. (Chapter 3 - Sections 3.1 to 3.2, Chapter 4 - Sections 4.1 to 4.4)

Module III (CO3) **(20 hours)**

General Measure Space and Measurable Functions: Measures and measurable sets, Signed Measures: The Hanh and Jordan decompositions, The Caratheodory measure induced by an outer measure, Measurable functions
(Chapter 17 - Sections 17.1 to 17.3, Chapter 18 - Section 18.1 up to corollary 7)

Module IV (CO4) **(20 hours)**

Integration over General Measure Space and Product Measures: Integration of non negative measurable functions, Integration of general measurable functions, The Radon Nikodym Theorem. (Chapter 18 - Sections 18.2 to 18.4)

Learning Resources:

Text Books:

H. L. Royden, P.M. Fitzpatrick, Real Analysis Fourth Edition, Pearson Education

References:

1. G. de Barra: Measure Theory and integration, New Age International (P) Ltd., New Delhi New Age International (P) Ltd., New Delhi,
2. Halmos P.R, Measure Theory, D.van Nostrand Co.
3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986(Reprint 2000).
4. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.

SEMESTER I11

CORE COURSE

MT3C13TM25 – Linear Algebra For Machine Learning

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Compute row echelon forms, matrix rank, and orthogonal basis sets using matrix operations and basic concepts of vector spaces. (A)

CO2: Apply properties of eigenvectors and diagonalization techniques to solve problems in machine learning and optimization. (A)

CO3: Explain different forms of singular value decomposition (SVD) (A)

CO4: Compare SVD-based techniques to distinguish their effectiveness in dimensionality reduction, noise removal, and feature engineering in machine learning. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	2	2	2
CO2	2	1	2	2	2
CO3	2	1	2	2	2
CO4	3	1	2	2	2

Syllabus Content

Module I (CO1) **(20 hours)**

Linear Transformation: Matrix Multiplication as a Decomposable Operator, The Geometry of Matrix Multiplication, Vector Spaces and Their Geometry, The Linear Algebra of Matrix Rows and Columns, The Row Echelon Form of a Matrix, The Notion of Matrix Rank, Generating Orthogonal Basis Sets, An Optimization-Centric View of Linear Systems, Ill-Conditioned Matrices and Systems.

(Relevant topics from section 1.3 and 2.2 to 2.9 of the text.)

Module II (CO2) **(20 hours)**

Eigenvectors and Diagonalizable matrices: Determinants, Diagonalizable Transformations and Eigenvectors, Machine Learning and Optimization Applications, The Power Method for Finding Dominant Eigenvectors.

(Section 3.2, 3.3.1 to 3.3.8, 3.4.2 to 3.4.4 and 3.5.2.)

Module III (CO3) **(25 hours)**

Singular Value Decomposition: Singular Value Decomposition of a Square Matrix, Square SVD to Rectangular SVD via Padding, Several Definitions of Rectangular Singular Value Decomposition, Truncated Singular Value Decomposition, Two Interpretations of SVD, Uniqueness, Two-Way Versus Three-Way Decompositions.
(Section 7.2.1 to 7.2.7)

Module IV(CO4) **(25 hours)**

SVD An optimization Perspective: Principal Component Analysis, Applications of Singular Value Decomposition: Dimensionality Reduction, Noise Removal, Finding the Four Fundamental Subspaces in Linear Algebra, Moore-Penrose Pseudoinverse, Solving Linear Equations and Linear Regression, Feature Preprocessing and Whitening in Machine Learning, Outlier Detection, Feature Engineering, Numerical Algorithms for SVD.
(Section 7.3.4, 7.4.1 to 7.4.8 and 7.5)

- As part of the assignment, students are required to maintain a record book. This book should cover related problems from all modules.

Learning Resources:

Text Books:

Charu C Aggarwal, Linear Algebra and Optimization for Machine Learning, Springer 2020

References:

1. G. Strang. Linear algebra and its applications, Fourth Edition. Brooks Cole, 2011.
2. D. Lay, S. Lay, and J. McDonald. Linear Algebra and its applications, Pearson, 2012.
3. G. Golub and C. F. Van Loan. Matrix computations, John Hopkins University Press, 2012.
4. S. Boyd and L. Vandenberghe. Convex optimization. Cambridge University Press, 2004
5. Noble, B., & Daniel, J. W. (1977). Applied linear algebra (Vol. 477). Englewood Cliffs, NJ: Prentice-Hall
6. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press
7. Strang, G. (2019). Linear algebra and learning from data (Vol. 4). Cambridge: Wellesley Cambridge Press.
8. Strang, G. (2016). Introduction to Linear Algebra (5th Edition). Wellesley Publishers (India), ISBN : 978-09802327-7-6.
9. G. Strang and K. Borre. Linear algebra, geodesy, and GPS. Wellesley-Cambridge Press, 1997.
10. H. Wendland. Numerical linear algebra: An introduction. Cambridge University Press, 2018.
11. C. Aggarwal. Outlier analysis. Springer, 2017.

SEMESTER III

CORE COURSE

MT3C14TM25 - Partial Differential Equations

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply various solution methods to solve differential equations, including Pfaffian differential equations and first-order partial differential equations, and utilize them in determining orthogonal trajectories on surfaces. (A)

CO2: Analyze first-order partial differential equations by classifying them into linear and nonlinear types, examining their geometric interpretations, and evaluating solution techniques. (An)

CO3: Apply appropriate methods to solve second-order partial differential equations with constant and variable coefficients. (A)

CO4: Apply the method of separation of variables to solve second-order nonlinear equations and Laplace's equation, and interpret solutions in terms of equipotential surfaces and logarithmic potential in function theory. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	3	1	1	1	2
CO3	2	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module I **(20 hours)**
Methods of solutions of dx/P = dy/Q = dz/R, Orthogonal trajectories of a system of curves on a surface, Pfaffian differential forms and equations, Solution of Pfaffian differential equations in three variables, Partial differential equations, Origins of first order partial differential equation.
(Chapter 1 - Sections 1.3 to 1.6, Chapter 2 - 2.1 to 2.2 of the text)

Module II **(25 hours)**

Linear equations of first order, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear partial differential equation of the first order, Compatible systems of first order equations. Charpit's Method, Special types of first order equations, Solutions satisfying given conditions, Jacobi's method.

(Chapter 2 - Section 2.4 to 2.7, 2.9 to 2.13 of the text)

Module III **(25 hours)**

The origin of second order equations, Linear partial differential equations with constant coefficients, Equations with variable coefficients

(Chapter 3 - 3.1, 3.4, 3.5 of the text)

Module IV **(20 hours)**

Separation of variables, Nonlinear equations of the second order, Elementary solutions of Laplace equation, Families of equipotential surfaces, The two-dimensional Laplace Equation, Relation of the Logarithmic potential to the Theory of Functions.

(Chapter 3 - Section 3.9 ,3.11, Chapter 4 - 4.2, 4.3,4.11,4.12 of the text)

Learning Resources:

Text Books:

Ian Sneddon, Elements of partial differential equations, McGraw Hill Book Company.

References:

1.Phoolan Prasad and Renuka Ravindran, Partial differential Equations, New Age International (p) Limited

2. K Sankara Rao, Introduction to Partial Differential Equations, Prentice-Hall of India

3. E. T Copson, Partial differential equations, S. Chand & Co

SEMESTER III

<u>CORE COURSE</u>

MT3C15TM25 – Advanced Graph Theory

Credits: 4

Total Lecture Hours: 90

CO1: Apply search, sorting, greedy algorithms, and graph representations to solve problems while implementing DFS, BFS, and minimum spanning tree algorithms. (A)

CO2: Analyze path-related properties and network flow principles to evaluate graph connectivity.(An)

CO3: Apply domination concepts to solve graph-based optimization problems. (A)

CO4: Analyze spectral properties of graphs using characteristic polynomials, adjacency matrix determinants, and graph energy. (An)

<u>Mapping of Course Outcomes with Program Specific Outcomes</u>

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	2
CO2	3	2	1	1	2
CO3	2	1	1	1	2
CO4	3	1	1	1	2

<u>Syllabus Content</u>

Module I (CO1) **(20 hours)**

An introduction to algorithms: Search algorithms, sorting algorithms, Greedy algorithms, representing graphs in a computer.

Trees: Properties of trees, rooted trees. Depth-first search, breadth – first search, the minimum spanning tree problem

(Chapter 2- Sections 2.1, 2.2, 2.3, 2.52.6 of the text 1)

(Chapter 3- sections 3.1 to 3.3.3.4 and 3.5 of the text 1)

Module II (CO2) **(25 hours)**

Paths and distance in graphs: Distance in a graphs, distance in weighted graphs, the centre and median of a graph. Activity digraphs and critical paths.

Networks: An introduction to networks. the max-flow min-cut theorem. the max-flow

min-cut algorithm, Connectivity and edge connectivity, Mengers theorem.
(Chapter 4 - sections 4.1 to 4.4 of the text 1)
(Chapter 5 - sections 5.1, 5.2, 5.3 and 5.5 of the text 1)

Module III (CO3) **(20 hours)**

Domination in Graphs: Introduction, Domination in Graphs, Bounds for the Domination Number, Bound for the Size m in Terms of Order n And Domination Number, Independent Domination and Irredundance.
Chapter 10-10.1 to 10.5 of the text 2)

Module IV (CO4) **(25 hours)**

Spectral Properties of Graphs: Introduction,The Spectrum of a Graph, Spectrum,of the Complete Graph Kn, Spectrum of the Cycle Cn, Coefficients of the Characteristic Polynomial, The Spectra of Regular Graphs, Th eSpectrum of the Complement of a Regular Graph, Spectra of Line Graphs of Regular Graphs, Spectrum of the Complete Bipartite Graph Kp;q,The Determinant of the Adjacency Matrix of Graph
The Energy of a Graph: Introduction,Maximum Energy of k-Regular Graphs,Hyperenergetic Graphs,Energy of Cayley Graphs,Energy of the Mycielskian of a Regular Graph
(Chapter 11-11.1 to 11.7, 11.12, 11.13 of the text 2)

Learning Resources:

Text Books:

Text 1- Gray Chartrand and O.R Oellermann, Applied and Algorithmic Graph Theory, Tata McGraw- Hill Companies Inc
Text 2- R. Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Second edition Springer

References:

1. Alan Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985
2. Mchugh. J.A, Algorithmic Graph Theory, Prentice-Hall, 1990 Golumbic. M, Algorithmic Graph Theory and Perfect Graphs, Academic press.
3. T.H. Cormen, Charles E. Leiserson, R.L. Rivest and C. Stein, Introduction to Algorithms, ThirdEdition, PHI Learning Private Limited, 2009
4. S. Dasgupta, C.H. Papadimitriou and U. Vazirani, Algorithms, First Edition, McGraw-Hill Education, 2006
5. U. Manber, Introduction to Algorithms: A Creative Approach, Addison-Wesley, 1989
6. A.V. Aho, J.E. Hopcroft and J.D. Ullman, Data Structures and Algorithms, Addison-Wesley,1983

John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.

7. Douglas B West, Introduction to Graph Theory, Prentice Hall of India.

8. Sheldon Axler, Linear algebra done right, Second edition, Springer.
9. J. A. Bondy, U.S.R. Murty: Graph Theory; Springer; 2000.
10. S. M. Cioaba and M.R. Murty: A First Course in Graph Theory and Combinatorics; Hindustan Book Agency; 2009.
11. R. Diestel: Graph Theory (4th Edn.); Springer-Verlag; 2010 [5] J. L. Gross: Graph theory and its applications (2nd edn.); Chapman & Hall/CRC; 2005.

SEMESTER IV

SEMESTER IV

CORE COURSE

MT4C16TM25 – Optimization Techniques

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply integer programming techniques such as branch-and-bound and cutting plane methods to solve ILP problems. (A)

CO2: Solve network flow problems using graph theory concepts, including shortest path, minimum spanning tree, and maximum flow, to optimize real-world network systems. (A)

CO3: Apply game theory concepts, including the minimax theorem, saddle points, and dominance strategies, to solve competitive decision-making problems. (A)

CO4: Analyze non-linear optimization techniques to solve constrained optimization problems. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	1	2
CO2	2	2	1	1	2
CO3	1	2	1	1	2
CO4	1	3	1	1	2

Syllabus Content

Module I (CO1) **(20 hours)**

Integer Programming: Introduction, I.L.P in two-dimensional space, General I.L.P. and M.I.L.P problems, Cutting planes, Remarks on cutting plane methods, Branch and bound method – examples, general description, The 0 – 1 variable problems.

(Chapter 6 - sections: 6.1 to 6.10 of the text 1)

Module II (CO2) **(25 hours)**

Flow and Potentials in Networks: Introduction, Graphs- definitions and notation, Minimum path problem, Spanning tree of minimum length, Problem of potential difference, Scheduling of sequential activities, Maximum flow problem, Duality in the maximum flow problem, Generalized problem of maximum flow.

(Chapter – 5 Sections 5.1 to 5.9 of the text 1)

Module III (CO3) **(20 hours)**

Theory of Games: Introduction, Matrix (or rectangular) games, Problem of game theory, Minimax theorem, saddle point, Strategies and pay off, Theorems of matrix games, Graphical solution, Notion of dominance, Rectangular game as an L.P. problem.

(Chapter 12 - Sections: 12.1 to 12.9 of the text 1)

Module IV (CO4) **(25 hours)**

Non- Linear Programming: Basic concepts, Taylor's series expansion, Fibonacci and Golden section search, Hooke and Jeeves search algorithm, Gradient projection, Lagrange multipliers, Equality constrained optimization - constrained derivatives, Projected gradient methods with equality constraints, Non-linear optimization- Kuhn-Tucker conditions, Quadratic Programming, Complimentary Pivot algorithms.

(Chapter 11- Sections: 11.1 to 11.11 of the text 2)

- As part of the assignment, students are required to maintain an assignment book. This book should cover related problems from all modules.

Learning Resources:

Text Books:

Text -1 K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3rd edition.

Text -2 Ravindran, Phillips and Solberg. Operations Research Principle and Practice, 2nd edition, John Wiley and Sons.

References:

1. S.S. Rao, Optimization Theory and Applications, 2nd edition, New Age International Pvt.

2. J.K. Sharma, Operations Research: Theory and Applications, 3rd edition, Macmillan India Ltd.

3. Hamdy A. Thaha, Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.

4. Singiresu S. Rao, Engineering Optimization: Theory and Practice, Fourth Edition, 2009, John Wiley & Sons, Inc.

ELECTIVE COURSES

SEMESTER IV

ELECTIVE COURSE

MT4E01TM25 – Advanced Complex Analysis

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the basic concepts of harmonic functions, such as the Mean-Value Property, Poisson's Formula, Schwarz's Theorem and Reflection Principle, to solve problems involving harmonic and subharmonic functions. (A)

CO2: Analyze the properties and behavior of complex functions using power series expansions, partial fractions, and factorization techniques. (An)

CO3: Examine the properties of the Riemann Zeta function and normal families. (A)

CO4: Explain the fundamental concepts of elliptic functions, including simply periodic and doubly periodic functions. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	2
CO2	3	1	1	1	2
CO3	2	1	1	1	2
CO4	3	1	1	1	2

Syllabus Content

Module I (CO1) **(20 hours)**

Harmonic Functions – Definitions and Basic Properties, The Mean-Value Property, Poisson's Formula, Schwarz's Theorem, The Reflection Principle.

A closer look at Harmonic Functions – Functions with Mean Value Property, Harnack's Principle.

The Dirichlet's Problem – Subharmonic Functions, Solution of Dirichlet's Problem (Proof of Dirichlet's Problem and Proofs of Lemma 1 and 2 excluded)

(Chapter 4 - Section 6: 6.1 to 6.5, Chapter 6 - Section 3: 3.1 to 3.2, Section 4: 4.1 to 4.2 of the text)

Module II (CO2) (25 hours)

Power Series Expansions – Weierstrass's theorem, The Taylor Series, The Laurent Series **Partial Fractions and Factorization** – Partial Fractions, Infinite Products, Canonical Products, The Gamma Function.
Entire Functions – Jensen's Formula, Hadamard's Theorem (Hadamard's theorem - proof excluded)
(Chapter 5 - Section 1: 1.1 to 1.3, Section 2: 2.1 to 2.4, Section 3: 3.1 to 3.2 of the text)

Module III (CO3) (25 hours)

The Riemann Zeta Function – The Product Development, The Extension of $\zeta(s)$ to the Whole Plane, The Functional Equation, The Zeroes of the Zeta Function.
Normal Families – Normality and Compactness, Arzela's Theorem (without proof).
The Riemann Mapping Theorem – Statement and Proof, Boundary Behaviour, Use of the Reflection Principle
(Chapter 5 - Section 4: 4.1 to 4.4, Section 5: 5.1 to 5.3, Chapter 6 - Section 1: 1.1to 1.3 of the text)

Module IV (CO4) (20 hours)

Elliptic functions: simply periodic functions, representation of exponentials, the Fourier development, functions of finite order.
Doubly periodic functions: The period module, unimodular transformations, the canonical basis, general properties of elliptic functions.
The Weierstrass's Theory: The Weierstrass's $\wp$- function, The functions $(z) and\ \sigma(z)$, The Differential Equation.
(Chapter 7 - Sections 1, 2, 3 of the text)

Learning Resources:

Text Books:

Complex Analysis – Lars V. Ahlfors (Third Edition), McGraw Hill Internationals

References:

1. Chaudhary B., The Elements of Complex Analysis, Wiley Eastern.
2. Cartan H., Elementary theory of Analytic Functions of one or several variable, Addison Wesley, 1973.
3. Conway J. B., Functions of one complex variable, Narosa publishing.

4. Lang S., Complex Analysis, Springer.
5. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990 6. T.W. Gamelin: Complex Analysis; Springer-Verlag, NY Inc.; 2001.
6. T.O. Moore and E.H. Hadlock: Complex Analysis, Series in Pure Mathematics-Vol. 9; World Scientific; 1991
7. L. Pennisi: Elements of Complex Variables (2nd Edn.); Holf, Rinehart & Winston 1976
8. H. Sliverman: Complex Variables; Houghton Mifflin Co. Boston; 1975.
9. R. Remmert: Theory of Complex Functions; UTM, Springer-Verlag, NY; 1991
10. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw - Hill

SEMESTER IV

ELECTIVE COURSE

MT4E02TM25– Number Theory and Cryptography

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze fundamental concepts of elementary number theory, including divisibility, the Euclidean algorithm, and congruences, and apply them to arithmetic computations and factoring problems. (An)

CO2: Apply the structure and properties of finite fields and quadratic residues in number-theoretic cryptographic techniques. (A)

CO3: Apply public key cryptographic methods, including RSA and discrete logarithms, to secure data transmission and encryption. (A)

CO4: Analyze primality testing and integer factorization techniques, including the rho method, Fermat factorization, and the quadratic sieve, for cryptographic and computational applications. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	1	2
CO2	2	2	1	1	2
CO3	2	2	1	1	2
CO4	2	3	1	1	2

Syllabus Content

Module 1 (CO1) **(28 hours)**

Some topics in Elementary Number Theory: -Time estimates for doing arithmetic, divisibility and the Euclidean algorithm, congruences, some applications to factoring.
(Chapter I – Sections 1, 2, 3 & 4 of the text)

Module 2 (CO2) **(14 hours)**

Finite Fields and Quadratic Residues: -Finite fields, quadratic residues and reciprocity (Chapter II - Sections 1 & 2 of the text)

Module 3 (CO3) **(25 hours)**

Public Key: - The idea of public key cryptography, RSA, Discrete log.
(Chapter IV - Sections 1, 2 & 3 of the text)

Module 4 (CO4) **(23 hours)**

Primality and Factoring: - Pseudoprimes, The rho method, Fermat factorization and factor bases, the quadratic sieve method.
(Chapter V - Sections 1, 2, 3 & 5 of the text)

Learning Resources

Textbooks:

Neal Koblitz, A Course in Number Theory and Cryptography, 2nd edition, Springer Verlag.

References:

1. Niven, H.S. Zuckerman and H.L. Montgomery, An introduction to the theory of numbers, John Wiley, 5th Edition.
2. Ireland and Rosen, A Classical Introduction to Modern Number Theory. Springer, 2nd edition, 1990.
3. David Burton, Elementary Number Theory and its applications, McGraw-Hill Education (India) Pvt. Ltd, 2006.
4. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press, 1996
5. Douglas R. Stinson, Cryptography Theory and Practice, Chapman & Hall, 2nd edition
6. Victor Shoup, A computation Introduction to Number Theory and Algebra, Cambridge University Press, 2005 7. William Stallings, Cryptography and Network Security Principles and Practice, Third edition, Prentice-hall, India.

SEMESTER IV

ELECTIVE COURSE

MT4E03TM25 – Differential Geometry

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Classify fundamental concepts in differential geometry, such as vector fields, tangent spaces, and surfaces, to analyze geometric structures. (An)

CO2: Apply concepts of the Gauss map, geodesics, and parallel transport to solve problems related to geometric properties. (A)

CO3: Develop geometric reasoning by computing curvatures, arc lengths, and line integrals, integrating knowledge from plane and surface geometry. (A)

CO4: Apply curvature properties to solve problems related to surface geometry and parametrized surfaces. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	2
CO2	2	1	1	1	2
CO3	2	1	1	1	2
CO4	2	1	1	1	2

Syllabus Content

Module 1(CO1) **(20 hours)**

Graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation.
(Chapters 1 to 5 of the text)

Module 2 (CO2) **(20 hours)**

The Gauss map, geodesics, Parallel transport
(Chapters 6, 7 & 8 of the text)

Module 3 (CO3) **(25 hours)**

The Weingarten map, curvature of plane curves, Arc length and line integrals
(Chapters 9, 10 & 11 of the text)

Module 4 (CO4) **(25 hours)**

Curvature of surfaces and Parametrized surfaces
(Chapters 12 & 14 of the text)

Learning Resources

Text Book: John A. Thorpe, Elementary Topics in Differential Geometry

References: -

1. Serge Lang, Differential Manifolds
2. I.M. Siger, J.A Thorpe, Lecture notes on Elementary topology and Geometry, Springer – Verlag, 1967.
3. S. Sternberg, Lectures on Differential Geometry, Prentice-Hall, 1964.
4. M. DoCarmo, Differential Geometry of curves and surfaces.
5. Goursat, Mathematical Analysis, Vol – 1(last two chapters)
6. M Spivak, Comprehensive introduction to Differential Geometry (Vols 1 to 5), Publish or Perish Boston

SEMESTER IV

ELECTIVE COURSE

MT4E04TM25- Multivariate Calculus And Integral Transforms

Total Credits: 3

Total Lecture Hours: 90

Course Outcome:

CO1: Apply Fourier series, Fourier integral theorem, and integral transforms to examine periodic functions and solve problems. (A)

CO2: Analyze the impact of multivariable differential calculus concepts, including directional derivatives, Jacobian matrices, and chain rules, in understanding function behavior and transformations. (An)

CO3: Apply the mean value theorem, differentiability conditions, and implicit function concepts to solve problems involving extrema of real-valued functions of one and several variables. (A)

CO4: Analyze the integration of differential forms and the implications of Stokes' theorem. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	2	2
CO2	3	2	2	1	2
CO3	2	2	1	1	2
CO4	3	2	1	1	2

Syllabus Content:

Module I (CO1) **(15 hours)**

The Weierstrass theorem, other forms of Fourier series, the Fourier integral theorem, the exponential form of the Fourier integral theorem, integral transforms and convolutions, the convolution theorem for Fourier transforms.

(Chapter 11 - Sections 11.15 to 11.21 of the text 1)

Module II (CO2) **(25 hours)**

Multivariable Differential Calculus The directional derivative, directional derivatives and continuity, the total derivative, the total derivative expressed in terms of partial derivatives, An application of complex- valued functions, the matrix of a linear function, the Jacobian matrix, the chain rule, matrix form of the chain rule.

(Chapter 12 - Sections. 12.1 to 12.10 of the text 1)

Module III (CO3) **(25 hours)**

The mean value theorem for differentiable functions, a sufficient condition for differentiability, a sufficient condition for equality of mixed partial derivatives, Implicit functions and extremum problems, functions with non-zero Jacobian determinant, the inverse function theorem (without proof), the implicit function theorem (without proof), extrema of real- valued functions of one variable, extrema of real- valued functions of several variables.

(Chapter 12 Sections-. 12.11 to 12.13. of the text 1)

(Chapter 13 Sections-. 13.1 to 13.6 of the text 1)

Module IV (CO4) **(25 hours)**

Integration of Differential Forms

Integration, primitive mappings, partitions of unity, change of variables, differential forms

(Chapter 10 Sections. 10.1 to 10.25 of the text 2)

Learning Resources:

Text Book:

Text 1: TOM APOSTOL, Mathematical Analysis, Second edition, Narosa Publishing House.

Text 2: WALTER RUDIN, Principles of Mathematical Analysis, Third edition – International Student Edition.

References:

1. Limaye Balmohan Vishnu, Multivariate Analysis, Springer.

2. Satish Shirali and Harikrishnan, Multivariable Analysis, Springer.

SEMESTER IV

ELECTIVE COURSE

MT4E05TM25- Combinatorics

Total Credits: 3

Total Lecture Hours: 90

Course Outcome:

CO1: Apply fundamental counting principles, permutations, and combinations to solve arrangement and distribution problems in combinatorics. (A)

CO 2: Analyze the Pigeonhole Principle and Ramsey numbers to determine combinatorial bounds and structured arrangements in problem-solving scenarios (An)

CO 3: Apply the Principle of Inclusion-Exclusion to compute integer solutions, shortest routes, surjective mappings, and Stirling numbers of the second kind. (A)

CO 4: Analyze generating functions and recurrence relations to study combinatorial structures and derive solutions for complex sequence-based problems. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	2
CO2	3	2	1	1	2
CO3	2	2	1	1	2
CO4	3	2	1	1	2

Syllabus Content:

Module I (CO1) **(22 hours)**

Permutations and Combinations: Two basic counting principles, Permutations, Circular permutations, Combinations, The injection and bijection principles, Arrangements and selection with repetitions, Distribution problems

(Chapter 1 of the text)

Module II (CO2) **(18 hours)**

The Pigeonhole Principle and Ramsey Numbers: Introduction, the pigeonhole principle, More examples, Ramsey type problems and Ramsey numbers, Bounds for Ramsey numbers

(Chapter 3 of the text)

Module III (CO3) **(25 hours)**

Principle of Inclusion and Exclusion: Introduction, The principle, A generalization, Integer solutions and shortest routes Surjective mappings and Sterling numbers of the second kind, Derangements and a Generalization

(Chapter -4 Sections 4.1 to 4.6 of the text)

Module IV (CO4) **(25 hours)**

Generating Functions: Ordinary generating functions, Some modelling problems, Partitions of integer, Exponential generating functions

Recurrence Relations: Introduction, Two examples, Linear homogeneous recurrence relations, General linear recurrence relations.

(Chapter 5, Chapter 6- Sections 6.1 to 6.4)

Learning Resources:

Text Book:

Chen Chuan -Chong, Koh Khee Meng, Principles and Techniques in Combinatorics, World Scientific, 1999.

References:

1. V Krishnamoorthy, Combinatorics theory and applications, E. Hoewood,1986
2. Hall,Jr, Combinatorial Theory, Wiley- Interscinice, 1998.
3. Brualdi, R A, Introductory Combinatorics, Prentice Hall,1992

SEMESTER IV

ELECTIVE COURSE

MT4E06TM25- Analytic Number Theory

Total Credits: 3

Total Lecture Hours: 90

Course Outcome:

CO1: Apply Dirichlet multiplication, Möbius inversion, and asymptotic formulas to analyze arithmetical functions, including the Möbius function, Euler's totient function, Mangoldt function, Liouville's function, divisor function, and completely multiplicative functions. (A)

CO2: Analyze Chebyshev's functions, prime number theorem, and Tauberian theorems to evaluate the distribution of prime numbers and derive asymptotic formulas for partial sums. (An)

CO3: Analyze the properties of congruences, residue systems, and polynomial congruences to evaluate solutions using Euler-Fermat's theorem, Lagrange's theorem, and the Chinese Remainder Theorem. (An)

CO4: Analyze integer partitions and modular arithmetic problems by interpreting primitive roots, exponentiation mod m, quadratic residues, generating functions, geometric representations, and Euler's pentagonal-number theorem. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	1	2
CO2	1	3	1	1	2
CO3	1	3	1	1	2
CO4	1	2	1	1	2

Syllabus Content:

Module I (CO1) **(30 hours)**

Arithmetic Functions Dirichlet Multiplication and Averages of Arithmetical functions introduction to Chapter1 of the text, the Mobius function the Euler totient function a relation connecting and the Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, the Mangoldt function , multiplicative e functions and Dirichlet multiplication, the inverse of completely multiplicative functions, the Liovillie's function , the divisor function , generalized convolutions, formal power series, the Bell series of an arithmetical function, Bell series and Dirichlet multiplication. Introduction to Chapter2 of the text, the big oh notation, asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, the average order of, The average order of the divisor function, average order of an application of distribution of lattice points visible from the origin, average order of, the partial sums of a Dirichlet product, application.

(Chapter 2 - sections 2.1 to 2.17, Chapter 3 - sections 3.1 to 3.11 of the text)

Module II (CO2) **(20 hours)**

Some Elementary Theorems on the Distribution of Prime Numbers Introduction to Chapter4, Chebyshev's functions and, relation connecting, some equivalent forms of prime number theorem, inequalities of and Shapiro's Tauberian theorem, applications of Shapiro's theorem, an asymptotic formula for the partial sum.

(Chapter 4 - sections 4.1 to 4.8 of the text)

Module III (CO3) **(25 hours)**

Congruences Definition and basic properties of congruences, residue classes and complete residue systems, linear congruences, reduced residue systems and Euler – Fermat theorem, Polynomial congruences modulo, Lagrange's theorem, applications of Lagrange's theorem, simultaneous linear congruences, the Chinese remainder theorem, applications of Chinese remainder theorem, polynomial congruences with prime power moduli

(Chapter 5- sections 5.1 to 5.9 of the text)

Module IV (CO4) **(15 hours)**

Primitive roots and partitions the exponent of a number mod m. Primitive roots, Primitive roots and reduced systems, The nonexistence of Primitive roots mod α 2 for 3 ≥ α, The existence of Primitive roots mod p for odd primes p, Primitive roots and quadratic residues. Partitions – Introduction, Geometric representation of partitions, Generating functions for partitions, Euler's pentagonal-number theorem.

(Chapter 10 - sections 10.1 to 10.5, Chapter 14 -sections 14.1 to 14.4 of the text)

Learning Resources:

Text Books:

Tom M Apostol, Introduction to Analytic Number Theory, Springer International Student Edition, Narosa Publishing House

References:

1. Hardy G.H and Wright E.M, Introduction to the Theory of numbers, Oxford, 1981
2. Leveque W.J, Topics in Number Theory, Addison Wesley, 1961.
3. J.P Serre, A Course in Arithmetic, GTM Vol. 7, Springer-Verlag, 1973

SEMESTER IV

ELECTIVE COURSE

MT4E07TM25- Operations Research

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Analyze problems to identify appropriate dynamic programming approaches, including when to use forward vs. backward recursion, and how to handle multiple constraints. (An)

CO2: Apply the formal definitions and theory of continuous-time random processes to solve real-world problems, such as calculating transition rates and defining state spaces in systems modeled by birth-death processes and Poisson processes. (A)

CO3: Analyze different types of queueing systems (e.g., M/M/1, M/M/c) and compare their performance by examining metrics like waiting time and queue length. (A)

CO4: Evaluate the effect of non-zero lead times on inventory models and recommend strategies for minimizing stock outs or excessive inventory. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	1	1	2
CO2	1	2	1	1	2
CO3	1	2	1	1	2
CO4	1	3	1	1	2

Syllabus Content

Module I (CO1) **(20 hours)**

Dynamic Programming: Introduction, Problem 1- Minimum path problem, Problem 2 -Single additive constraint, additively separable return, Problem 3– Single multiplicative constraint, additively separable return, Problem 4- Single additive constraint, multiplicatively separable return, Computational economy in DP, Serial multistage model, Examples of failure, Decomposition, Backward and forward recursion, Systems with more than one constraint, Applications of D.P to continuous systems.

(Chapter 10 - Sections 10.1 to 10.12 of the text 1)

Module II (CO2) **(20 hours)**

Continuous time random processes an example, Formal definitions and theory, the assumptions reconsidered, Steady state probabilities, Birth death processes, The Poisson process.

(Chapter 6 - Sections 6.11 to 6.16 of the text 2)

Module III (CO3) **(25 hours)**

Queueing Systems Introduction, An example, General Characteristics, Performance Measures, Relations Among the performance Measures, Markovian Queueing Models, The M/M/1 Model, Limited Queue Capacity, Multiple Servers, An example, Finite Sources.

(Chapter 7 - Sections 7.1 to 7.11 of the text 2)

Module IV (CO4) **(25 hours)**

Inventory Models Introduction the Classical Economic Order Quantity, A Numerical example, Sensitivity Analysis, Non-Zero lead Time, The EOQ. with shortages allowed The Production Lot size (PLS) models, The Newsboy Problem (a single period model), A Lot size reorder point model, Variable lead times, the importance of selecting the right model.

(Chapter 8 - Sections: 8.1 to 8.14 of the text 2)

Learning Resources:

Text Books:

Text 1: K.V. Mital and C. Mohan, Optimization Methods in Operations Research and System Analysis, 3rd edition, New Age International Pvt. Ltd.

Text 2: A. Ravindran, Don T. Philips and James J. Solberg., Operations Research Principles and Practice, 2nd edition, John Wiley and Sons.

References:

1. Fundamentals of Queueing Theory, Donald Gross, Carl M. Harris, 3rd edition, John Wiley and Sons.
2. Hamdy A. Taha, Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.
3. Man Mohan, P.K. Gupta and Kanti Swarup, Operations Research, Sultan Chand and Sons.

SEMESTER IV

ELECTIVE COURSE

MT4E08TM25- Probability Theory

Total Credits: 3

Total Lecture Hours: 90

Course Outcome:

CO1: Apply probability axioms, rules, inequalities, and Bayes' theorem to compute probabilities, assess conditional events, and determine independence. (A)

CO2: Apply the concepts of random variables, probability distributions, expectation, moments, generating functions, and moment inequalities to solve probabilistic problems. (A)

CO3: Apply properties of multiple random variables, including independence, covariance, correlation, expectation inequalities, and conditional expectation, to solve problems in probability models. (A)

CO4: Analyze different modes of convergence in sequences of random variables and evaluate their implications using the Laws of Large Numbers and the Central Limit Theorem. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	2
CO2	2	2	1	1	2
CO3	2	2	1	1	2
CO4	3	2	1	1	2

Syllabus Content:

Module I (CO1) **(25 hours)**

Introduction and different approaches to probability, Probability Axioms - Addition rule, Principle of inclusion and exclusion, Bonferroni's inequality, Boole's inequality, Implication rule, Sequence of events and their limits, Conditional Probability, Multiplication rule on Probability, Baye's Theorem, Independence of Events, Borel 0-1 Criterion.

Text Book 1: - Sections 1.2, 1.3 (till Remarks 5), 1.5, 1.6

Text Book 2: -Sections 9.3(b)

Module II (CO2) **(25 hours)**

Random variable, Probability distribution, Discrete and Continuous random variables, Function of a random variable, Expectation and Moments of a random variable, Generating Functions, Moment inequalities – Markov's inequality, Chebychev- Bienayme's inequality, Lyapunov's inequality.

Text Book 1: - Chapters 2- Section 2.1 to 2.5(till example 7) and Chapter 3 –Section 3.2 except proofs of Theorem 4,5,6, Section 3.3, Section 3.4)

Module III (CO3) **(20 hours)**

Multiple random variables, Independence of random variables, Covariance and Correlation and moments, Addition and Multiplication theorems on expectation, Cr inequality, Holder's inequality, Cauchy- Schwartz's inequality, Jensen's inequality, Minkowski's inequality, Conditional expectation.

Text Book 1: Sections 4.2 to 4.3 (till example 6), 4.5 (till theorem 6 including its Corollary 1 and 2, 4.6.

Text Book 2: Section 5.3 (c) and (d).

Module IV (CO4) **(20 hours)**

Convergence of sequence of random variables – Convergence in law, Convergence in probability, Convergence in rth mean, Convergence almost surely. Weak Law of Large Numbers-Kintchine's Weak Law of Large Numbers, Strong Law of Large Numbers-Kolmogrov strong law of large numbers, Central Limit Theorem- Lindberg - Levy form and Liapunov's form of Central Limit Theorem. (simple application problems)

Text Book 1: Section 6.2 (till Theorem 12), For the remaining part of the module reference may be done from any of the Text Books 1, 2 or 3.

Learning Resources:

Text Books:

Text 1: V.K (2001) An Introduction to Probability and Statistics, 2ndEdn, Wiley India (P) Ltd, New Delhi.

Text 2: Bhat B.R (1999) Modern Probability Theory, 3rdEdn, New Age International (P) Ltd, New Delhi.

Text 3: S.C Gupta and V.K Kapoor (2002) Fundamentals of Mathematical Statistics, 11^{th} Edn, Sultan Chand & Sons, New Delhi.

References:

1. Feller W. (1976) An Introduction to Probability Theory and Its Applications, Vol. 2, Wiley India (P) Ltd.
2. Mukhopadhyay, P. (2011) An Introduction to the Theory of Probability, World Scientific Publishing Company.
3. Billingsley P. (1985) Probability and Measure, Wiley India (P) Ltd.
4. Laha R.G and Rohatgi V.K (1979) Probability Theory, Wiley India (P) Ltd.
5. Loeve M (1963) Probability Theory, Allied East – West Press.

SEMESTER IV

ELECTIVE COURSE

MT4E09TM25- Coding Theory

Total Credits: 3

Total Lecture Hours: 90

Course Outcome:

CO1: Apply the concepts of weight, maximum likelihood decoding, and perfect codes to analyze error-detecting and error-correcting capabilities in coding theory. (A)

CO2: Analyze the properties of self-dual codes, Golay codes, and BCH codes to distinguish their role in reliable data transmission and error correction (An).

CO3: Apply the algebraic structure of finite fields to construct error-correcting codes in communication systems. (A)

CO4: Analyze cyclic codes and BCH codes to evaluate their efficiency and effectiveness in correcting multiple errors in digital communication. (An)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	2
CO2	2	3	1	2	2
CO3	2	2	1	2	2
CO4	2	3	1	2	2

Syllabus Content:

Module I (CO1) **(25 hours)**

Introduction Basic Definitions Weight, Maximum Likelihood decoding Synarome decoding, Perfect Codes, Hamming codes, Sphere packing bound, more general facts.

(Chapter 1, Chapter 2 - Sections 2.1, 2.2, 2.3 of the text)

Module II (CO2) **(20 hours)**

Self-dual codes, The Golay codes, A double error correction BCH code and a field of 16 elements.

(Chapter 2 - Section 2.4, Chapter 3 of the text)

Module III (CO3) **(20 hours)**

Finite fields

(Chapter 4 of the text)

Module IV (CO4) **(25 hours)**

Cyclic Codes, BCH codes

(Chapter 5 , Chapter 7 of the text)

Learning Resources:

Text Books:

Vera Pless 3rd Edition, Introduction to the theory of error coding codes, Wiley Inter Science

References:

1. R-Lidi, G. Pliz, Applied Abstract Algebra, Springer Verlag.
2. J.H.Van Lint, Introduction to Coding Theory, Springer Verlag
3. R.E.Blahut, Error- Control Codes, Addison Wesley.

SEMESTER IV

MT4PRM25- Project

Total Credits: 5

Course Outcome:

CO1: Apply mathematical concepts and techniques to solve complex real-world or theoretical problems. (A)

CO2: Employ appropriate research methodologies and ethical practices to conduct mathematical investigations. (A)

CO3: Create mathematical models and computational simulations using advanced analytical techniques and software tools. (C)

CO4: Interpret research findings effectively through well-structured written reports and oral Presentations. (A)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	2
CO2	2	2	2	1	2
CO3	1	2	2	2	3
CO4	1	1	3	1	2

Guidelines for Project Report

- All students shall prepare and submit project report as part of the programme.
- The project of the PG program should be relevant and innovative in nature.
- The type of project can be decided by the student and the guide (a faculty of the department or other department/ college/ university/ institution).
- The project should be aimed to motivate the inquisitiveness and research aptitude of the students.
- The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV.
- The students may either present the results of the project in seminars/symposia or publish in a reputed journal
- The project is evaluated by one external and one internal examiner.

SEMESTER IV

MT4VM25 - Comprehensive Viva-Voce

Total Credits: 2

Course Outcome:

CO1: Evaluate the depth of conceptual knowledge of the subject through critical assessment and logical reasoning. (E)

CO2: Assess the clarity, coherence, and effectiveness of verbal communication in presenting mathematical concepts and solutions. (E)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2
CO2	3	3	2	2	2

Guidelines for Comprehensive Viva

- A comprehensive viva voce examination will be conducted by one external and one internal examiner at the time of evaluation of the project.
- The components of viva consist of subjects of special interest, fundamental concepts, topics covering all semesters and awareness of current and advanced topics.

****