SYLLABUS

DIBRUGARH UNIVERSITY

FOUR YEARS UNDER GRADUATE PROGRAMME (FYUGP)
[AS PER NEP 2020]

MATHEMATICS

(Recommended by B.O.S. in Mathematics, D.U. in its meetings held on 18.11.2022, 10.02.2023 & 09.02.2024 and approved by Joint UG-PG Board meeting held on 06/06/2024 and passed by the Academic Council meeting held on 13/06/2024 and effective from the session 2023-24)

PREAMBLE

As recommended by the University Grants Commission (UGC) and proposed for implementation by Dibrugarh University, the Department of Mathematics works to implement the relevant components of New Education Policy (NEP), 2020 for Four Year Under Graduate Programme (FYUGP). The following facts are taken into consideration when designing the basic structure of the Under Graduate (UG) programme:

i. Flexibility to switch between disciplines of study,
ii. Opportunity for learners to select the courses of their interest across all disciplines,
iii. Flexible entry and exit options with UG certificates, UG diplomas, or UG degrees depending on the number of credits earned,
iv. Flexibility for students to switch between institutions so they can engage in multi- and/or interdisciplinary learning,
v. Flexibility to switch to alternative modes of learning,
vi. Knowledge required for self-employment initiatives and entrepreneurship mindset,
vii. Ability for complex critical thinking and real-life problem solving,
viii. Capability to understand global issues, multicultural competence and digital literacy,
ix. Capable on research skills, communication skills, community based engagement, environment awareness, responsibility and accountability.

INTRODUCTION

The Under Graduate (UG) syllabus of Mathematics in light of New Education Policy (NEP), 2020 consists of Major (Core) disciplines, Minor disciplines, Multi-Disciplinary Generic Elective Courses (MDGEC), Ability Enhancement Courses (AEC), Value Added Courses (VAC), Skill Enhancement Courses (SEC), Research Ethics and Methodology, Dissertation (Collection of Data, Analysis and Preparation of Report) and Discipline Specific Electives (DSE).

The UG degree programme offers certificates, diplomas and degrees as follows:

UG Certificate: Certificate course consists of two Major disciplines, two Minor disciplines, two MDGEC, two AEC, two VAC and two SEC.

UG Diploma: Diploma course consists of eight Major disciplines, four Minor disciplines, three MDGEC, two AEC, three VAC, three SEC.

3-year UG Degree: 3-year UG degree course consists of fifteen Major disciplines, six Minor disciplines, three MDGEC, two AEC, three VAC, three SEC, Community engagement (NCC/NSS/Adult Education/Student mentoring/ NGO/ Govt. Institutions, etc.) and Internship.

4-year Honours Degree: 4-year honours degree course consists of twenty Major disciplines, eight Minor disciplines, three MDGEC, two AEC, three VAC, three SEC, Community engagement (NCC/NSS/Adult Education/Student mentoring/ NGO/ Govt. Institutions, etc.), Internship, Research Ethics and Methodology/ two DSE.

AIM

The UG Programme in mathematics is designed to teach students how to think critically, logically, and analytically, which enables them to employ mathematical reasoning in real-world situations. A UG degree in mathematics will expose students to a variety of intriguing and practical concepts that will help them in their preparation for a variety of mathematics-oriented jobs in industry, government, business, commerce, finance and research.

The programme covers broad range of topics on pure and applied mathematics. Also covers hands-on sessions in Computer Lab using various software, MATLAB, C etc. which enables students to corelate and compare with recent developments in various branches of mathematics in a variety of organisations worldwide.

The programme aims to increase students' skill in mathematics as well as other cross-disciplinary subjects like commerce, physics, computer sciences, economics, and statistics etc. Also aims students' flexibility to move from one discipline to another, to move one institution to another, to switch alternative modes of learning.

Programme Educational Objectives (PEO):

PEO 1: Fundamental Knowledge and Skills

Graduates will be well-versed in mathematical theories, concepts, and techniques, enabling them to solve challenging problems and pursue advanced study in mathematics or related fields.

PEO 2: Analytical and Critical Thinking

Graduates will acquire the analytical and critical thinking abilities needed to formulate, evaluate, and resolve real-world issues using logical reasoning and mathematical modelling.

PEO 3: Application of Mathematics

Graduates will be adept at using computational tools and mathematical concepts to solve problems in a variety of sectors, including science, engineering, technology, and economics.

PEO 4: Communication and Collaboration

Graduates will be able to effectively convey mathematical concepts, both orally and in writing, as well as collaborate in multidisciplinary teams to solve challenging problems.

PEO 5: Ethical and Professional Responsibilities

Graduates will exhibit a dedication to moral behaviour and professional obligations, which include comprehending how mathematical solutions affect society and maintaining a high standard of professional development.

PEO 6: Lifelong Learning and Adaptability

Graduates will pursue lifelong learning in order to keep up with new developments and trends in the mathematics and to adjust to the changing needs of both academia and the workforce.

PEO 7: Research and Innovation

Graduates will be equipped with the capacity to carry out autonomous research, enhancing their understanding of mathematics and stimulating their imagination in addressing abstract and practical issues.

PROGRAMME OUTCOMES ARE GRADUATE ATTRIBUTES STATED AS FOLLOWS:

PO1: Disciplinary Knowledge

Being able to demonstrate comprehensive knowledge and coherent understanding of both the theoretical and applied components of mathematics as well as chosen interdisciplinary areas of study in a broad multidisciplinary context.

PO2: Communication Skills

Capability to express various mathematical ideas clearly through computational methods, graphical methods, examples and their geometrical representations; ability to use mathematics effectively as a precise language of communication in other fields.

PO3: Moral and Ethical Awareness/Reasoning

Ability to recognise ethical issues that are pertinent to one's work and pledge not to engage in unethical behaviour such as plagiarism, copyright and infringement of intellectual property rights.

PO4: Multicultural Competence

Ability to corelate and compare recent developments in various branches of mathematics in a variety of organisations worldwide; ability to effectively participate in a multicultural group or society and interact politely with diverse groups.

PO5: Information/Digital Literacy

Ability to access, asses and utilize Information and Communications Technology (ICT) tools. Ability to understand, read and write programming language/packages/modules (MATLAB; C) for computation, simulation, graphs and solutions.

PO6: Reflective Thinking

Ability to formulate appropriate questions pertaining to the ideas in various branches of mathematics in order to propose new solutions using the domain knowledge of mathematics; ability to interpret the findings and use them to solve a variety of problems found in numerous fields of mathematics and real-life.

PO7: Cooperation/Team Work

Ability to collaborate with diverse teams in an effective and respectful manner; capacity to cooperate with people from varied backgrounds in the interests of a common goal.

PO8: Research Related Skills

The ability to formulate appropriate questions, problems, and hypotheses by analysing and interpreting the ideas from various branches of mathematics; ability to demonstrate the results, theories, techniques and proofs using the concepts of various fields of mathematics.

PO9: Problem Solving

Ability to work independently and do in-depth study to find ways that mathematics is used in various industries and in daily life to improve job possibilities in a wide range of fields and academic study; ability to use innovative, imaginative, lateral thinking, interpersonal skills, and emotional intelligence; ability to tackle various challenges in both familiar and unfamiliar circumstances, then apply what they've learned to actual scenarios.

PO10: Critical Thinking

Capability to analyse and synthesise theoretical and applied problems, as well as acquire knowledge and skills through logical reasoning, analytical thinking and evaluations; ability to find gaps and logical faults in arguments; inculcate a healthy attitude to be a lifelong learner.

Programme Specific Outcomes:

The Programme Specific Outcomes of FYUGP programme in Mathematics are listed in the following. After completing the programme the students will be able to-

PSO1: Demonstrate the acquisition of comprehensive knowledge and coherent understanding in chosen elective and core subjects in mathematics.

PSO2: Apply mathematical techniques and tools, such as mathematical modeling, computational methods, and statistical analysis, to solve real-world problems in various fields.

PSO3: Possess strong analytical and critical thinking skills, enabling them to construct rigorous logical arguments, develop proofs, and solve complex mathematical problems.

PSO4: Proficient in using modern mathematical software and computational tools such as MATLAB, C, and other relevant technologies to analyze data and solve mathematical problems.

PSO5: Communicate mathematical ideas and solutions to a variety of audiences, including mathematicians, scientists, engineers, and non-specialists, both orally and in writing.

PSO6: Formulate research questions, literature review, methodology, presentation of findings, and demonstrate dedication to lifelong learning and professional development.

PSO7: Utilize the skills that necessary for success in national level competitive exams, pursuing doctoral research degree, teaching and others.

Teaching Learning Process:

The outcome-based approach demands a considerable transition from teacher centric to learner centric pedagogies, as well as from passive to active/participatory pedagogies, especially in the context of undergraduate study. This course promotes the systematic and sequential acquisition of knowledge and skills. It also focuses on practical abilities, as well as an awareness of the link between theory and practice. Teaching strategies involve discussions, presentations, use of required textbooks, e-learning tools, other self-study materials; project, internship, exploring industrial needs and other research activities and so on.

Assessment Methods:

A variety of assessment procedures appropriate for the Mathematics discipline will be used to determine how well students are progressing keeping in view of the programme outcomes. Continuous evaluation will decide the final grade which include both in-semester evaluation and the final exam. In-semester evaluation will consist of class exams, mid-term exams, homework assignments, etc. as determined by the concerned teacher of the course of study. The following techniques will be used to evaluate how successfully students are meeting their goals: tutorials, timed exams, problem-based assignments, lab reports for practical assignments, observations of practical skills, individual project reports, team project reports, oral presentations, including seminar presentations, viva voce interviews, group discussions, quiz and so on.

STRUCTURE OF FOUR YEAR UNDER GRADUATE PROGRAMMES (FYUGP) IN MATHEMATICS FOR DIBRUGARH UNIVERSITY AND ITS AFFILIATED COLLEGES (AS PER NEP-2020 GUIDELINES)

Semester	Course	Title of the Paper &Paper Code		Credit
I (FIRST)	**MTHC-1**	Calculus and Classical Algebra		4
	MINMTH-1	Differential Calculus		4
	GECMTH-1A	Foundation in Mathematics-I	**ANY ONE**	3
	GECMTH-1B	History of Mathematics		
	AEC 1	AEC Language: MIL/ Regional Language		4
	SEC 115	Computer Laboratory-I		3
	VAC 1	Value Added Course 1		2
	Total Credit			**20**
II (SECOND)	**MTHC-2**	Real Analysis & Differential Equation		4
	MINMTH-2	Real Analysis		4
	GECMTH-2A	Foundation in Mathematics-II	**ANY ONE**	3
	GECMTH-2B	Business Mathematics		
	AEC 2	AEC: Language and Communication Skills (English) II		4
	SEC 214	Computer Laboratory-II		3
	VAC 2	Value Added Course 2		2
	Total Credit			**20**
III (THIRD)	**MTHC-3**	Theory of Real functions		4
	MTHC-4	Group Theory I		4
	MINMTH-3	Differential Equations		4
	GECMTH-3A	Mathematical Finance	**ANY ONE**	3
	GECMTH-3B	Combinatorial Mathematics		
	SEC-315	Mathematical Logic		3
	VAC 3	Value Added Course 3		2
	Total Credit			**20**

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Semester	Course	Title of the Paper &Paper Code		Credit
IV (FOURTH)	**MTHC-5**	Numerical Methods		4
	MTHC-6	Riemann Integration & Series of Functions		4
	MTHC-7	Ring Theory and Linear Algebra I		4
	MTHC-8	PDE and Systems of ODE		4
	MINMTH-4	Algebra		4
	Total Credit			**20**
V (FIFTH)	**MTHC-9**	Multi-Variate Calculus		4
	MTHC-10	Group theory-II		4
	MTHC-11A	Linear Programming	**ANY ONE**	4
	MTHC-11B	Mathematical Methods		
	MTHC-11C	Financial Mathematics		
	MTHC-11D	Computer Programming		
	MINMTH-5	Computer Programming		4
	INTERNSHIP OR COMMUNITY ENGAGEMENT	Internship* or		4
		Community Engagement (NCC/NSS/Adult Education/ Student Mentoring/NGO/Govt. Institutions, etc.)*		
	Total Credit			**20**
VI (SIXTH)	**MTHC-12**	Metric Spaces & Complex Analysis		4
	MTHC-13	Ring Theory & Linear Algebra II		4
	MTHC-14A	Number Theory	**ANY ONE**	4
	MTHC-14B	Mechanics		
	MTHC-14C	Hydro-Mechanics		
	MTHC-15A	Discrete Mathematics	**ANY ONE**	4
	MTHC-15B	Probability and Statistics		
	MINMTH-6	Numerical Methods		4
	Total Credit			**20**

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Semester	Course	Title of the Paper &Paper Code		Credit
VII (SEVENTH)	**MTHC-16**	Field Theory		4
	MTHC-17	Tensor Analysis		4
	MTHC-18	Theory of Equations		4
	MINMTH-7	Advanced Mathematical Logic		4
	MTH7RM	Research Methodology		4
	Total Credit			**20**
VIII (EIGHTH)	**MTHC-19**	Functional Analysis		4
	MTHC-20	Non-linear Dynamical System & Chaos		4
	DISSERTATION OR ANY TWO FROM MTH8D-1, MTH8D-2, MTH8D-3 & MTH8D-4			
	MTH8D	Dissertation*		8
	MTH8D-1	Finite Element Methods	**ANY TWO**	4
	MTH8D-2	Fluid Dynamics		4
	MTH8D-3	Information Security		4
	MTH8D-4	Fuzzy Set Theory		4
	MINMTH-8	Probability and Statistics		4
	Total Credit			**20**

***As per Dibrugarh University Guidelines.**

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Calculus and Classical Algebra**
Course Code	**:**	**MTHC1**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisite:

- Ideal of fundamentals of differentiation and integration,
- Trigonometric and logarithmic functions,
- Arithmetic.

Course Objectives:

The course will introduce to the learners the concept of De Moivre's Theorem and its application in the expansion of some trigonometric functions. Students will learn the techniques of successive differentiation, Leibnitz theorem, and L'Hospital rule for evaluation of limit. It will explain various types of reduction formula for integration of trigonometric function and applications in finding the volume and surface area of revolution of curve. The course will also introduce the system of linear equation and how to solve such systems.

Course outcomes: After completing the course a learner will be able to

CO1: Apply De'Moivre theorem to different problems.

ILO 1.1: Demonstrate the use of De'Moivre's theorem in raising complex numbers to powers and extracting roots.
ILO 1.2: Solve problems involving the trigonometric form of complex numbers using De'Moivre's theorem.

CO2: Discuss expansion of trigonometric and hyperbolic functions.

ILO 2.1: Derive the series expansions for sine, cosine, and hyperbolic sine, and cosine functions.
ILO 2.2: Analyze the convergence of trigonometric and hyperbolic function expansions.

CO3: Apply Leibniz theorem to obtain successive differentiation.

ILO 3.1: Utilize Leibniz's theorem to find higher-order derivatives of product functions.
ILO 3.2: Solve problems involving successive differentiation using Leibniz's rule.

CO4: Utilize L'Hospital rule in finding limit of quotient of functions.

ILO 4.1: Apply L'Hospital's rule to evaluate limits of indeterminate forms such as 0/0 and ∞/∞.
ILO 4.2: Analyze and solve problems involving limits where L'Hospital's rule is applicable.

CO5: Evaluate maxima and minima of functions.

ILO 5.1: Determine the critical points of a function and classify them as maxima, minima, or saddle points.
ILO 5.2: Apply the first and second derivative tests to find and verify local maxima and minima of functions.

CO6: Describe reduction formula involving both trigonometric and logarithmic functions

ILO 6.1: Develop reduction formulas for integrals involving trigonometric functions.
ILO 6.2: Apply reduction formulas to solve integrals involving logarithmic functions.

CO7: Evaluate length of curves and area & volume of revolution of curves.

ILO 7.1: Calculate the arc length of a given curve using integral formulas.
ILO 7.2: Evaluate the area and volume generated by rotating a curve around an axis using integral methods.

CO8: State well ordering property of positive integers and fundamental theorem of Algebra.

ILO 8.1: Explain the well-ordering property of positive integers and its implications.
ILO 8.2: State and apply the fundamental theorem of algebra in solving polynomial equations.

CO9: Apply Division and Euclidean Algorithm to find GCD.

ILO 9.1: Use the Division Algorithm to express the gcd of two integers as a linear combination.
ILO 9.2: Implement the Euclidean Algorithm to determine the greatest common divisor of two integers.

CO10: Describe congruence relation between integers.

ILO 10.1: Explain the concept of congruence relations and their properties.
ILO 10.2: Solve problems involving modular arithmetic using congruence relations.

CO11: Demonstrate row reduction and echelon form of matrix.

ILO 11.1: Perform row operations to transform a matrix into row echelon form.
ILO 11.2: Demonstrate the process of reducing a matrix to its reduced row echelon form.

CO12: Solve system of linear equations.

ILO 12.1: Apply matrix methods, such as Gaussian elimination, to solve systems of linear equations.
ILO 12.2: Utilize the inverse matrix method and Cramer's rule to find solutions to systems of linear equations.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO8	CO2	X	X	CO6	X
CONCEPTUAL	C10	X	CO3, CO11, CO12	X	CO5	X
PROCEDURAL	X	CO1, CO4	CO9	X	CO7	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (11 Marks)	De Moivre's Theorem with rational indices and its application to various problems, Expansion of sinx, cosx, sinhx and coshx and related problems.	09	03	-	12
II (11 Marks)	Successive Differentiation, Leibnitz Theorem and its application, L'Hospital's Rule, Applications of maxima & minima, Definition of partial differential equations and examples.	09	03	-	12
III (11 Marks)	Reduction Formulae of the types $\int \sin^n x dx, \int \cos^n x dx, \int \tan^n x dx, \int (\log x)^n dx$ and $\int \sin^m x \cos^n x dx$ and their derivations. Rectification, volume and surface area of revolution of a curve.	09	03	-	12
IV (11 Marks)	Composite and invertible functions, well ordering property of positive integers, Division algorithm, Divisibility & Euclidean algorithm, Congruence relation between integers, Statement of the Fundamental Theorem of Arithmetic.	09	03	-	12
V (16 Marks)	System of Linear Equations, Row Reduction and Echelon Form, Vector Equation and matrix equation $Ax = b$. Solution set of a linear system, Linear Dependence and Independence of vectors.	09	03	-	12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Das B.C.& Mukherjee B.N., Higher Trigonometry, U N Dhur & Sons, 1933.
2. Thomas G.B. & Finney R.L., Calculus, Pearson Education, 2007.
3. Burton, D.M. Elementary Number Theory, McGraw Hill, 7th Ed., 2023.

REFERENCE BOOKS:

1. Arumugam S., Somasundaram A., & Isaac A.T., Differential Calculus, CBS Publishers, 2021.
2. Greenhill A.G., Differential and Integral Calculus, Alpha Edition, 2020.
3. Khanna V.K.& Bhambri S.K., Abstract Algebra, Vikash Publishing, 2017.
4. Lay David C., Lay S.R., & McDonald J.J., Linear Algebra and Its Application, Pearson, 2015.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	L	L	M	L	M	S	S
CO2	S	S	L	L	L	S	M	S	S	S
CO3	S	S	L	L	L	M	L	M	S	S
CO4	S	S	L	L	L	M	L	M	S	S
CO5	S	S	L	M	L	S	M	S	S	S
CO6	S	S	L	L	L	S	M	M	S	S
CO7	S	S	L	L	L	M	L	M	S	S
CO8	S	S	L	L	L	M	L	M	S	S
CO9	S	S	L	L	L	M	L	M	M	S
CO10	S	S	L	L	L	S	M	M	S	S
CO11	S	S	L	L	L	S	M	S	S	S
CO12	S	S	L	M	L	S	S	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Differential Calculus**
Course Code	**:**	**MINMTH 1**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Differential Calculus deals with the outline of basic concepts of differential calculus and its application in solving various problems.

Pre-requisite:

- Ideal of fundamentals of limit, continuity and differentiation.
- Exponential, trigonometric and logarithmic functions,
- Arithmetic.

Course Objective:

The objectives of the course are

i. To introduce the important concept of calculus and their applications
ii. To apply Rolles theorem, mean value theorem etc. in various problems

Course Outcome:

On successful completion of the course, the students will be able to

CO1: define limit, continuity and differentiability and solve the problems

ILO 1.1: Analyse the continuity and differentiability of a function

ILO 1.2: Use Leibinitz theorem to find the higher order differentiation of products of functions.

CO2: get the knowledge of partial differentiations and evaluate partial differentials

ILO 2.1: Evaluate the partial differentials of a function

ILO 2.2: Discuss and use Euler's theorem on homogeneous functions.

CO3: apply differential calculus in finding tangent, normal etc. and trace a curve

ILO 3.1: find the equation of tangent and normal of any curve

ILO 3.2: Use calculus to determine the curvature of a curve

ILO 3.3: Discuss the steps to trace a curve.

CO 4: analyse Rolle's theorem, mean value theorem etc. and interpret them

ILO 4.1: Give a geometrical interpretation of Rolle's theorem.

ILO 4.2: Construct the Taylor/ Maclaurin series of a given function.

ILO 4.3: Assess the maxima and minima of a function.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO1					
Conceptual Knowledge			CO1	CO4		
Procedural Knowledge	CO3		CO2		CO4	
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Limit and Continuity (ε- δ definition), Types of discontinuity, Differentiability of functions, Successive differentiation.	09	03	-	12
II (12 Marks)	Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions.	09	03	-	12
III (18 Marks)	Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.	12	04	-	16
IV (18 Marks)	Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(l+x)^m$, Maxima and Minima, Indeterminate forms.	15	05	-	20
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment

- Group Discussion
- Quiz
- Viva-Voce

TEXTBOOKS:

1. Anton H., Bivens I. & Davis S., Calculus, John Wiley and Sons Inc., 2002.
2. Thomas G.B. & Finney R.L., Calculus, Pearson Education, 2007.

REFERENCE BOOK:

1. Arumugam S., Somasundaram A., & Isaac A.T., Differential Calculus, CBS Publishers, 2021.

Mapping of Course Outcome to Program Outcome

CO/PO	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	S	S	M
CO2	S	S	M	M	M	M	M	S	S	M
CO3	S	S	M	M	M	M	M	S	S	M
CO4	S	S	M	M	M	M	M	S	S	M

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-I**
Course Code	**:**	**GECMTH1A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Foundation in Mathematics is a unique course to initiate the students to some fundamental topics of Mathematics. This course equips students with mathematical tools and techniques, the study of the logical and philosophical basis of mathematics, including whether the axioms of a given system ensure its completeness and its consistency. Topics include sets and logic, relation and functions, calculus and differential equations. This course prepares students for advanced studies in mathematical logic, calculus and their various applications by developing skills, strategies and reasoning needed to succeed in mathematics.

Pre-Requisites:

- Introduction to Sets and Logic.
- Basic concepts of calculus.
- Key concepts of relation and functions.

Course Objectives:

The course on Foundation in Mathematics-I aims the students to achieve in a more practical and definite ways. This sets the stage for more advanced mathematical concepts and real-world applications. The goal is to capture from specific and numeric reasoning to general and abstract reasoning using the language and structure of algebra to investigate, represent, and solve problems.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Interpret and communicate quantitative information and mathematical and statistical concepts.
ILO1.1: Achieve a solid understanding of using estimation skills and when to estimate results.
ILO1.2: Read, interpret, and make decisions about data summarized numerically.
ILO1.3: Demonstrate proficiency in using basic terminology and principles.

CO2: Understanding the fundamental concepts of logic and set theory and apply the knowledge to everyday matters.
ILO2.1: Analyze the logical structure of statements symbolically, including the proper use of logical connectives, predicates, and quantifiers.
ILO2.2: Evaluate the truth of a statement using the principles of logic.
ILO2.3: Properly use the vocabulary and symbolic notation of higher mathematics in definitions, theorems, and problems.

CO3: Explore how relations and functions are applicable in daily life.

ILO3.1: Identify and differentiate between reflexive, symmetric, transitive and equivalence relations.

ILO3.2: Define one-to-one and onto functions and apply them in real-life scenarios.

ILO3.3: Analyze and interpret real-life examples such as in social networks, transportation systems, etc.

CO4: Understand the foundation of calculus and its applications in mathematics and physics.

ILO4.1: Interpret equations and graphs of the basic classes of functions.

ILO4.2: Evaluate limits by using limit laws and other evaluation techniques.

ILO4.3: Apply differentiation to geometric application, physical application, and modelling problems.

CO5: Systematic approach for solving problems and finding solutions in various fields, from physics to finance.

ILO5.1: Recognise differential equations and use the appropriate method to solve them.

ILO5.2: Use an initial condition to find a particular solution of a differential equation.

ILO5.3: Solve problems involving exponential growth and decay.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		CO4
Procedural Knowledge			CO1, CO2	CO3	CO4	CO5
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (12 Marks)	**Sets and Logic** Sets, subsets, types of set, operations on sets, Cartesian product, Statements, truth values and truth table, negation, conjunction and disjunction, Statements with quantifiers, compound statements, implications, biconditional proposition, converse, contrapositive and inverse proposition, propositional equivalence, predicates and quantifier, tautology and contradiction.	06	03	-	9
II (18 Marks)	**Relation and Functions** Relation and functions, types of relation and functions, graphs of functions, compositions of functions and invertible function, Binary operations.	08	04	-	12

III (15 Marks)	**Calculus** Limits, continuity, Differentiability of function, Derivatives of different types of functions, second order derivatives, rate of change of quantities, increasing and decreasing function, Maxima and Minima, introduction to Integrals, Applications of integrals.	08	04	-	12
IV (15 Marks)	General and particular solutions of differential equations, separation of variables, Homogeneous equations, Linear Differential Equations of first order, General and particular solutions of homogeneous and non-homogeneous linear differential equations of second order with constant coefficients.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Kumar A., Kumaresan S., &Sarma, B.K., A Foundation Course in Mathematics, Narosa Publishing House, 2018.
2. Stewart I., Tall D., The Foundations of Mathematics. Oxford University Press, 2nd Ed., 2015.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	L	M	S	M	M	S
CO2	S	S	M	M	L	M	M	S	S	M
CO3	S	S	M	M	L	M	M	S	S	M
CO4	S	M	M	M	L	M	S	M	S	S
CO5	S	M	M	M	L	M	S	S	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**History of Mathematics**
Course Code	**:**	**GECMTH1B**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The History of Mathematics course explores the development of mathematical concepts, theories, and practices from ancient civilizations to modern times. This course examines the contributions made by important historical eras and individuals to a variety of mathematical disciplines, including number theory, calculus, geometry, and algebra. The cultural and historical settings in which these mathematical concepts originated and developed will become more clear to the students. Students will understand mathematics' influence on science, technology, and society as well as its continuing influence on modern mathematical thought by exploring the discipline's historical development.

Pre-Requisites:

- Basic concepts of arithmetic operations.
- Introduction to geometry.

COURSE OBJECTIVE:

1. To develop a comprehensive understanding of the origins and development of mathematics in ancient India, medieval India, including the contributions of Hindu and Greek mathematicians.
2. To study the evolution of major mathematical concepts and theories in areas like algebra, geometry, calculus, and number theory.
3. To analyze how the technological, social, and cultural environments shaped the conceptualization of mathematics.
4. To gain an understanding of how mathematical discoveries have impacted society, science, and technology.

Course Outcome:

After going through this course, the students will be able to

CO1: describe and analyze the development and significance of mathematics in ancient India, focusing on Hindu contributions and their historical context.

ILO1: Identify and describe significant mathematical contributions from ancient India, such as advancements in algebra, trigonometry, and arithmetic.

ILO2: Examine the cultural, religious, and intellectual environment in which Hindu mathematicians made their contributions.

ILO3: Highlight the lives and works of prominent Hindu mathematicians such as Aryabhata, Brahmagupta, and Bhaskara II.

ILO4: Explain how Hindu mathematical discoveries influenced later mathematical developments in India and other regions.

CO2: analyze the development of numeral systems, including the decimal place-value system, zero symbol, and various numerical notations in Hindu literature.

ILO1: Describe the progression from early numerical notations to the development of the decimal place-value system.

ILO2: Discuss the introduction and impact of the zero symbol and its role in the decimal place-value system.

ILO3: Explain how the Hindu numeral system, including the concept of zero, spread and influenced other cultures and mathematical systems.

ILO4: Analyze different numerical notations used in ancient Hindu texts and their applications.

CO3: apply Euclidean geometry principles by exploring Euclid's "Elements," including the Pythagorean Theorem and geometric algebra.

ILO1: Describe the foundational principles and axioms of Euclidean geometry as presented in Euclid's "Elements."

ILO2: Detail the Pythagorean Theorem and various proofs, including those found in Euclid's "Elements."

ILO3: Discuss how Euclid applied geometric methods to solve algebraic problems, demonstrating the concept of geometric algebra.

CO4: evaluate Archimedes' methods for estimating pi and his contributions to geometry.

ILO1: Explain the techniques Archimedes used to approximate the value of pi, including the method of exhaustion.

ILO2: Discuss key geometric discoveries and theories proposed by Archimedes, such as the area of a circle and the surface area of a sphere.

ILO3: Investigate how Archimedes' work in geometry and pi estimation influenced later mathematicians and the development of mathematics.

CO5: synthesize knowledge of arithmetic algorithms, geometry, linear congruences, sine tables, and Diophantine equations, tracing their development and transmission in ancient and medieval India.

ILO1: Describe important arithmetic algorithms, such as those for multiplication and division, used in ancient India.

ILO2: Detail how linear congruences were formulated and solved in ancient Indian mathematical texts.

ILO3: Examine the development of sine tables and their importance in the work of Indian mathematicians like Aryabhata.

ILO4: Investigate the techniques and algorithms used by Indian mathematicians to solve Diophantine equations and their impact on number theory.

ILO5: Explore how mathematical discoveries from ancient and medieval India were transmitted to other cultures and influenced global mathematics.

Cognitive Map of Course Outcomes with Bloom's Taxonomy:

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE		CO1	CO3		CO4	
CONCEPTUAL KNOWLEDGE	CO1		CO3	CO2	CO4	
PROCEDURAL KNOWLEDGE			CO3	CO1; CO2	CO4	
METACOGNITIVE KNOWLEDGE					CO5	

UNITS	CONTENTS	L	T	P	Total Hours
I (9 Marks)	A glimpse of ancient India; Hindus and mathematics; Scope and development of Hindu mathematics.	06	03	-	09
II (15 Marks)	Numeral terminology; The development of Numerical Symbol; The decimal place-value system; Persistence of the old system; Word numerals; Alphabetic notations; The zero symbol; The place-value notation in Hindu literature.	08	04	-	12
III (18 Marks)	Euclid: Introduction to the Elements; Book I and Pythagorean Theorem; Book II and Geometric Algebra. Archimedes; Estimating the values of pi. Ramanujan's view on Magic square.	08	04	-	12

IV (18 Marks)	Ancient and Medieval India: Arithmetic algorithms; Geometry; Linear congruence; Construction of Sine tables; Transmission to and from India. Diophantine Equations in Greece and India; Early Mathematics in India. Linear Equations in One and Two unknown. The Rule of three.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Datta B., Narayan Singh A., History of Hindu Mathematics (Part I), Gyan Publishing House, 2021.
2. Kartz Victor J., A History of Mathematics: An Introduction, Pearson, 2009.
3. Burton David M., The History of Mathematics: An Introduction, Mc Graw Hill, 2011.
4. Berndt Bruce C., Ramanujan's Notebooks: Part I, Springer, 1985.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	M	M
CO2	S	S	M	M	L	M	M	M	M	M
CO3	S	S	M	M	L	S	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	S	M	S	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Computer Laboratory-I**
Course Code	**:**	**SEC115**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=6)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an in-depth understanding of advanced mathematical concepts and techniques, with a focus on practical applications using Matlab or Mathematica. The course covers fuzzy sets, basic commands and operations in Matlab/Mathematica, solutions of algebraic equations, evaluation of mathematical expressions, techniques of sketching conics, and matrix operations. Students will engage in hands-on practical sessions to reinforce theoretical knowledge and develop problem-solving skills in real-world contexts.

Prerequisites

- Basic understanding of high school mathematics, including algebra, trigonometry, and calculus.
- Introductory knowledge of programming or computational tools is recommended.

Course Objectives

1. **Develop Mathematical Reasoning:** Enhance students' ability to reason mathematically and understand fundamental mathematical axioms.
2. **Comprehend and Expand Mathematical Concepts:** Enable students to comprehend and build upon basic and advanced mathematical concepts.
3. **Logical Analysis and Theorem Crafting:** Equip students with skills to analyze and craft logical arguments to substantiate mathematical theorems.
4. **Advanced Mathematical Knowledge:** Provide deep insights into various mathematical domains, including fuzzy sets and parametric curves.
5. **Problem-Solving Methodologies:** Master diverse problem-solving methodologies applicable to mathematical issues.
6. **Effective Communication:** Develop proficiency in communicating mathematical ideas with precision and clarity.
7. **Professional and Applied Mathematics Skills:** Enhance professional mathematical skills and gain expertise in specialized areas of applied mathematics.
8. **Computational and Research Skills:** Acquire necessary mathematical and computational skills for engaging in independent research.
9. **Real-Life Problem-Solving:** Prepare students to address real-life and complex mathematical problems using advanced techniques.
10. **Technical Report Preparation:** Train students to prepare clear and precise technical mathematical reports, such as dissertations and theses.

Course Outcomes (COs)

On successful completion of the course, the students will be able to

CO1: Demonstrate proficiency in using basic commands in Matlab/Mathematica to evaluate mathematical expressions and solve algebraic equations.

ILO1: explain the function of basic commands in Matlab/Mathematica such as clc, help, clear, format, exit, linspace, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, and commands for trigonometric and inverse trigonometric functions.

ILO2: Apply basic commands in Matlab/Mathematica to evaluate mathematical expressions, including arithmetic operations, exponential and logarithmic functions, trigonometric functions, and computation of complex numbers.

CO2: Analyze graphs of various functions and polynomials using Matlab/Mathematica to understand their properties.

ILO1: Explain the use of graph plotting commands in Matlab/Mathematica, such as plot, title, legend, hold on, axis, grid on, figure, clf, and close all.

ILO2: Apply Matlab/Mathematica commands to plot and analyze graphs of various functions and polynomials, including linear, quadratic, exponential, logarithmic, trigonometric functions, and polynomials of degrees 4 and 5.

ILO 3: Analyze the Behavior of Various Functions

CO3: Utilize techniques for sketching conics and parametric curves using Matlab/Mathematica to explore their geometric properties.

ILO1: explain the use of commands in Matlab/Mathematica for sketching conics and parametric curves, such as ezplot, fplot, plot, and other relevant plotting functions.

ILO2: Apply Matlab/Mathematica commands to sketch and analyze the geometric properties of conics (e.g., ellipses, hyperbolas) and parametric curves (e.g., cycloids, epicycloids, hypocycloids).

CO4: Apply Matlab/Mathematica to obtain surfaces and volumes of revolution and perform matrix operations.

ILO1: Use Matlab/Mathematica to calculate and visualize surfaces and volumes of revolution for given functions.

ILO2: Utilize Matlab/Mathematica to perform matrix operations, including addition, multiplication, inversion, and transposition.

CO5: Interpret the procedural steps involved in using Matlab/Mathematica for various mathematical computations.

ILO1: Explain the procedural steps for performing basic mathematical computations in Matlab/Mathematica, such as evaluating expressions, solving equations, and plotting graphs.

ILO2: Demonstrate interpreting of the procedural steps for advanced mathematical computations in Matlab/Mathematica, including matrix operations, solving systems of equations, and performing calculus operations.

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge				CO2		
Procedural Knowledge		CO5	CO1, CO3, CO4			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	Basic commands of Matlab or Mathematica, Evaluation of different mathematical Expressions, Solutions of algebraic equation. **List of Practicals** 1. Basic commands of Matlab or Mathematica: clc, help, clear, format, exit, line space, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, commands for trigonometric and inverse trigonometric function, abs, exp, sqrt, log, log2, log10, mod, plot, title, legend, hold on, axis, grid on, figure, clf, close all. 2. Evaluation of arithmetic expression, exponential and logarithms, trigonometric functions, computation of complex numbers. 3. Solution of algebraic equation, simultaneous linear equations.	-	00	15x2	30
II (12 Marks)	Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **List of Practicals** 5. Plotting of graphs of function $e^{ax + b}$, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax +b), |ax + b| and to illustrate the effect of a and b on the graph. 6. Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.	-	00	07x2	14
III (12 Marks)	Techniques of sketching conics, polar equation of conics 1. Sketching parametric curves (E.g., Trochoid, cycloid, epicycloids, hypocycloid).	-	00	08x2	16

IV (18 Marks)	2. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, hyperbolic paraboloid using cartesian coordinates. Surface and volume of revolution, polar equation of conics, Matrix operations. **List of Practicals** 1 Obtaining surface of revolution of curves. 2 Tracing of conics in Cartesian coordinates/ polar coordinates. 3 Matrix operations (addition, multiplication, inverse, transpose).	-	00	15x2	30
	Total			**45X2**	**90**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Pratap Rudra, Getting started with MATLAB: A quick Introduction for Scientist and Engineers, Oxford University Press, 2010.
2. Wolfram S., The Mathematica, Cambridge University Press, 2003.
3. Thomas G.B. & Finney R.L., Calculus, 9th Ed., Pearson Education, Delhi, 2005.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	S	M	S	S	S	S
CO2	M	S	S	M	S	S	S	S	S	S
CO3	M	M	S	S	S	M	S	S	S	S
CO4	M	M	M	S	S	M	S	S	S	S
CO5	M	M	M	S	S	S	S	S	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis and Differential Equations**
Course Code	**:**	**MTHC2**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Real Analysis & Differential Equations has two parts. The first part includes axioms of real number systems, review of the algebraic and order properties of the set R of real numbers. Sequences and their types with their convergence and divergence properties. The second part includes the various solution concepts of differential equations and their properties. The whole course is so designed that the students will learn the theories and concepts used in the real analysis and also the tools to solve differential equations.

Prerequisites:

- Introduction to Set Theory
- Calculus

Course Objectives:

The course on Real Analysis & Differential Equations is designed for the students to demonstrate theoretical knowledge and have problem solving skills on topics of Real Analysis & Differential Equations. The course will describe appropriate theorems, principles and concepts relevant to Real Analysis in the first section and Differential Equations in the second section. Both these sections provide a background for the study of mathematical analysis and also the application of differential equations in other branches of studies.

Course Outcomes (COs):

On successful completion of the course, the students will be able to

CO1: Demonstrate the Algebraic, Order and the Completeness properties of the real numbers.

ILO1.1: List the algebraic and order properties of real numbers.

ILO1.2: Find supremum and infimum of sets.

ILO1.3: Describe Archimedean principle and its corollaries.

ILO1.4: Explain the properties of countable and uncountable sets.

CO2: Examine the convergence of real sequences and series.

ILO 3.1: Discuss the basic convergence properties of sequences and series.

ILO 3.2: Determine convergence and divergence of sequences and series.

ILO 3.3: Apply Archimedean principle in obtaining convergence of sequences and series.

CO3: Execute various solution concepts of differential equations

ILO 3.1: Classify the general, particular, explicit, implicit and singular solutions of differential equations.

ILO 3.2: Solve Exact differential equations, linear equations and Bernoulli equations.

ILO 3.3: Apply the solution methods of differential equations to solve problems.

CO4: Describe the solution techniques of homogeneous and non-homogeneous differential equations of second order

ILO 4.1: Solve homogeneous and non-homogeneous linear differential equations.

ILO 4.2: Solve Euler equations.

ILO 4.3: Solve differential equations using method of undetermined coefficients and method of variation of parameters.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO2	CO1, CO2				
Conceptual Knowledge		CO3	CO1,CO2	CO2		
Procedural Knowledge		CO3, CO4	CO1, C03, CO4	CO3, CO4		
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
	(A) Real Analysis				
I (15 Marks)	Review of Algebraic and Order Properties of R, -neighborhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.	12	04	-	16
II	Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences,	12	04	-	16

(15 Marks)	Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. Statements of Infinite series, convergence and divergence of infinite series, Cauchy Criterion.				
	(B) Differential Equations				
III (12 Marks)	Concepts and definition of General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.	09	03	-	12
IV (18 Marks)	General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Bartle R.G. & Sherbert D.R., Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore,2002.
2. Kumar A.& Kumarasen S., A Basic Course in Real Analysis, CRC Press, Reprint 2021.
3. Ross S.L., Differential Equations, 3rd Ed., John Wiley and Sons, India,2004.

REFERENCE BOOKS:

1. Thomas G.B. & Finney R.L., Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. Coddington E. A., An Introduction to Ordinary Differential Equation, Dover Publications, 1989.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	L	M	M	S	S	S
CO2	S	S	M	S	L	S	S	M	M	S
CO3	S	M	M	S	L	S	M	S	S	S
CO4	M	S	S	M	L	S	M	M	M	M

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis**
Course Code	**:**	**MINMTH2**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Real Analysis includes axioms of real number systems, sequence and series and their convergence. It is so designed that the students will learn the theories and concepts used in the real analysis. It also recognizes the contribution and impacts of real analysis in different areas of science.

Prerequisites:

- Introduction to Set Theory
- Calculus

Course Objectives:

The course on Real Analysis is designed for the students to demonstrate theoretical knowledge and have problem solving skills on topics of Real Analysis. The course will describe appropriate theorems, principles and concepts relevant to Real Analysis and provide a background for the study of Functional Analysis, Measure Theory, Topology, etc. It will deal with problems relevant to topics related to Real Analysis using ideas and techniques some of which are at the forefront of the discipline.

Course Outcomes (COs):

On successful completion of the course, the students will be able to

CO1: Demonstrate the Algebraic, Order and the Completeness properties of the real numbers.

ILO1.1: List the algebraic and order properties of real numbers.

ILO1.2: Find supremum and infimum of sets.

ILO1.3: Deduce results as corollaries to the properties of the real numbers.

CO2: Examine the convergence of real sequences and series.

ILO2.1: Deduce Cauchy's convergence criterion and apply it to determine whether a sequence is convergent or not.

ILO2.2: Deduce monotone convergence theorem and apply it determine whether a sequence is convergent or not.

ILO2.3 Apply Archimedean principle in obtaining convergence of sequences.

CO3: Apply standard tests for convergence of sequences and series.

ILO 3.1: Describe Comparison test, Root test, Ratio test, Leibnitz's test of convergence.
ILO 3.2: Apply Comparison test, Root test, Ratio test, Leibnitz's test to determine whether a sequence is convergent or not.
ILO 3.3: Define absolute and conditional convergence with examples.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO2	CO1, CO2				
Conceptual Knowledge		CO3	CO1	CO1, CO3		
Procedural Knowledge		CO3	CO1, CO2, CO3			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Finite and infinite sets, examples of countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.	09	03	-	12
II (18 Marks)	Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).	15	05	-	20
III (12 Marks)	Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, convergence of p-series, alternating series,	09	03	-	12

IV (15 Marks)	Comparison test, Root test, Ratio test, Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Kumar A. & Kumarasen S., A Basic Course in Real Analysis, CRC Press, Reprint, 2021.
2. Bartle R.G. & Sherbert D.R., Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore,2002.

REFERENCE BOOKS:

1. Fischer E., Intermediate Real Analysis, Springer Verlag,1983.
2. Ross K.A., Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	L	M	M	S	S	S
CO2	S	S	M	S	L	S	S	M	M	S
CO3	S	M	M	S	L	S	M	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-II**
Course Code	**:**	**GECMTH2A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, P=0, T=1)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Foundation in Mathematics is a unique course to initiate the students to some fundamental topics of Mathematics. This course equips students with mathematical tools and techniques, the study of the difference operator with their relation and interpolation of function for the set of tabulated points. Topics include counting principles, numerical and probability. This course prepares students for advanced studies by developing skills, strategies and reasoning needed to succeed in mathematics.

Pre-Requisites:

- Introduction to Permutation and Combination.
- Basic concepts of operators.
- Introduction to Probability.

Course Objectives:

The course on Foundation in Mathematics-II aims the students to achieve in a more practical and definite ways. This sets the stage for more advanced mathematical concepts and real-world applications. The goal is to capture from specific and numeric reasoning to general and abstract reasoning using the language and structure of algebra to investigate, represent, and solve problems.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Apply systematic strategies to count possible outcomes.
ILO1.1. Apply counting principles in a fair and unbiased manner.
ILO1.2: Read, interpret, and make decisions about data summarized numerically.
ILO1.3: Evaluate skills for both academic and real-world problem solving.

CO2: Understanding the fundamental concepts of interpolation methods.
ILO2.1: Use of various interpolation methods, including linear, polynomial, and spline interpolation.
ILO2.2: Understand their applications and limitations.
ILO2.3: Evaluate the accuracy and sources of interpolation error.

CO3: Understand the basic concepts of probability, random variables.
ILO3.1: Concept of random variables and distinguish between discrete and continuous types.
ILO3.2: Calculate the expected value, and variance of random variables.

ILO3.3: Analyze and interpret uncertain or random phenomena in real-world situations.

CO4: Understand the foundation of economic models, market analysis, and final forecasting.
ILO4.1: Develop critical thinking and data literacy skills.
ILO4.2: Evaluate data critically, discerning between reliable and unreliable information.
ILO4.3: Make predictions based on statistical models.

CO5: Use moment generating functions to find moments.

ILO5.1: Apply probability models to real-world problems in fields.

ILO5.2: Construct and interpret confidence intervals for parameter estimates.

ILO5.3: Stochastic processes, statistical learning and actuarial science.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		CO5
Procedural Knowledge			CO1, CO2	CO3		CO5
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	**Counting Principles** Sum and Product rule of counting, permutation and combination, multinomial theorem, Pigeon hole principle, inclusion-exclusion principle, set partitions.	08	04	-	12
II (18 Marks)	**Finite Differences and Interpolation** Introduction, forward difference operator, Operators E & D, backward differences, central differences, Newton' forward and backward interpolation formulae, Lagrange's interpolation formula.	10	05	-	15
III (15 Marks)	**Probability** Introduction to probability, Random experiment, event, axiomatic approach to probability, conditional probability, Multiple theorem on probability, Bayes' theorem (Statement Only with Applications), random variables and distributions.	08	04	-	12

IV (9 Marks)	**Statistics** Introduction to statistics, Measure of Central Tendency.	04	02	-	06
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Rao, G. S., Numerical Analysis. New Age International Publishers, 2003.
2. Berge, C., Principles of Combinatorics. New York, 1971.
3. Stewart I., Tall D., The Foundations of Mathematics. Oxford University Press, 2015.
4. Shastry S.S., Introductory Methods of Numerical Analysis, PHI, 2012.
5. Ross, S. M., Introduction to probability and statistics for engineers and scientists, Elsevier, 2021.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	M	M	S	M	M	S
CO2	S	S	M	M	M	S	M	S	S	M
CO3	S	S	S	M	M	S	M	S	M	M
CO4	S	M	S	M	M	S	S	M	S	S
CO5	S	M	S	M	M	S	S	S	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Business Mathematics**
Course Code	**:**	**GECMTH2B**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Business Mathematics is a vital subject that equips students with mathematical tools and techniques used in business and finance. The course covers fundamental concepts such as matrices, calculus, and finance, with a focus on their applications in business scenarios. Topics include linear equations, functions, matrices, differential calculus, and financial mathematics. This course prepares students for advanced studies in finance, business, and economic challenges by honing their analytical and mathematical skills, which are required for a successful career in business.

Pre-Requisites:

- Introduction to Real Analysis.
- Basic concepts of matrices.
- Basic concepts of financial mathematics.

COURSE OBJECTIVE:

1. To develop a solid understanding of fundamental mathematical concepts, including algebra, calculus, and finance, and their relevance to business applications.
2. To develop mathematical skills to solve real-world business problems using linear equations, functions, and matrices.
3. To enhance computational skills in differential calculus to optimize business functions and analyze changes in business environments.
4. To develop analytical and problem-solving skills by working through practical business scenarios and mathematical models.
5. To enhance mathematical and analytical skills to prepare for further studies in business, finance, and economics.

COURSE OUTCOME:

After going through this course, the students will be able to

CO1: apply matrix algebra, including calculating determinants, adjoints, and inverses, to solve simple business and economic problems.

ILO1: Compute the determinant of a matrix and explain how it can be used to determine the solvability of a system of linear equations in business applications.

ILO2: Calculate the adjoint of a given matrix and demonstrate its use in finding the inverse of the matrix for business problem-solving.

ILO3: Find the inverse of a matrix and use it to solve linear systems related to business and economic problems.

ILO4: Apply matrix operations such as addition, subtraction, multiplication, and inversion to model and solve business and economic problems.

CO2: analyze mathematical functions, including linear, quadratic, and polynomial, by applying the concepts of limits, continuity, and differentiation.

ILO1: Analyze the limits of linear, quadratic, continuity and polynomial functions in business contexts.

ILO2: Apply differentiation to linear, quadratic, and polynomial functions to determine marginal costs, revenues, and other rates of change in business scenarios.

ILO3: Apply differentiation techniques to solve optimization problems in business, such as maximizing profit or minimizing cost.

CO3: apply concepts of simple and compound interest, and different types of interest rates to perform compounding and discounting of sums.

ILO1: Apply the simple interest formula to determine interest amounts and total sums for different business investments and loans.

ILO2: Use the compound interest formula to calculate future values and present values of business investments and savings accounts.

ILO3: Calculate the compounded amount of investments over multiple periods using different interest rates.

CO4: formulate linear programming problems (LPP) based on business scenarios and sketch graphs of linear equations and inequalities.

ILO1: Define the decision variables and constraints for a given business problem to formulate a linear programming model.

ILO2: Express business constraints as linear inequalities and incorporate them into the linear programming model.

ILO3: Draw graphs of linear equations and inequalities to visually represent the feasible region of a linear programming problem.

CO5: evaluate and solve linear programming problems using graphical methods to find optimal solutions.

ILO1: Plot the feasible region of a linear programming problem on a graph based on the given constraints.

ILO2: Determine the coordinates of the corner points (vertices) of the feasible region and understand their significance in finding the optimal solution.

ILO3: Calculate the value of the objective function at each corner point to identify the optimal solution for the linear programming problem.

Cognitive Map of Course Outcomes with Bloom's Taxonomy:

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE			CO1, CO3		CO5	CO4
CONCEPTUAL KNOWLEDGE			CO1, CO3	CO2	CO5	CO4
PROCEDURAL KNOWLEDGE			CO1, CO3	CO2	CO5	
METACOGNITIVE KNOWLEDGE						

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	**Matrices** Definition of a matrix. Types of matrices; Algebra of matrices. Calculation of values of determinants up to third order; Adjoint of a matrix; Finding inverse of a matrix through ad joint; Applications of matrices to solution of simple business and economic problems	08	04	-	12
II (18 Marks)	**Differential Calculus** Mathematical functions and their types – linear, quadratic, polynomial; Concepts of limit and continuity of a function; Concept of differentiation; Rules of differentiation – simple standard forms. Applications of differentiation – elasticity of demand and supply; Maxima and Minima of functions (involving second or third order derivatives) relating to cost, revenue and profit.	08	04	-	12

III (15 Marks)	**Basic Mathematics of Finance** Simple and compound interest Rates of interest – nominal, effective and continuous – their inter relationships; Compounding and discounting of a sum using different types of rates.	08	04	-	12
IV (12 Marks)	**Linear Programming** Sketching of graphs of (i) Linear equation ax + by + c=0 and (ii) Linear inequalities. Formulation of linear programming problem (LPP). Graphical solution to LPP.	06	03		09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Vohra N.D., Business Mathematics and Statistics, McGraw Hill Education (India) Pvt. Ltd, 2012.
2. Singh J. K., Business Mathematics, Himalaya Publishing House, 2021.

REFERENCE BOOKS:

1. Mizrahi A., Sullivan M., Mathematics for Business and Social Sciences: Applied approach. Wiley and Sons, 1976.
2. Thukral J.K., Mathematics for Business Studies, Mayur Publications, 2009.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low (‘Low’) contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	S	S	S	S	S
CO2	S	S	M	M	L	S	M	M	S	S
CO3	S	S	M	M	L	S	S	M	S	S
CO4	S	S	M	M	L	S	M	S	S	S
CO5	S	S	M	M	L	S	S	S	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Computer Laboratory-II**
Course Code	**:**	**SEC214**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=6)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

• Basic understanding of differential equations, calculus, and programming concepts.

Course Objectives:

The objectives of this course are:

- To model various real-life problems, such as exponential decay models, lake pollution models, etc., using MATHEMATICA/MATLAB/Open-source software.
- To plot recursive sequences and sequences of partial sums using MATHEMATICA/MATLAB.

Course Outcomes (COs):

On successful completion of the course, the students will be able to

CO1: Utilize modeling techniques to solve real-life problems such as exponential decay and lake pollution using MATHEMATICA/MATLAB.

ILO1: Explain the steps to model exponential growth and decay problems using MATHEMATICA/MATLAB.

ILO2: Apply modeling techniques to solve the lake pollution model and interpret the results.

CO2: Interpret recursive sequences and sequences of partial sums to understand their convergence properties.

ILO1: Use MATHEMATICA/MATLAB to plot recursive sequences and study their convergence.

ILO2: Interpret the behavior of sequences of partial sums to determine convergence or divergence.

CO3: Implement and study drug assimilation models and limited growth population models.

ILO1: Interpret drug assimilation into the blood using MATHEMATICA/MATLAB.

ILO2: Apply modeling techniques to limited growth population models and analyze the impact of harvesting.

CO4: Apply ecological and epidemiological models.

ILO1: Implement predatory-prey models and analyze the population dynamics.

ILO2: Utilize epidemic scenarios using MATHEMATICA/MATLAB and interpret the spread of disease.

CO5: Verify mathematical theorems and concepts through plotting and analysis.

ILO1: Explain MATHEMATICA/MATLAB to verify the Bolzano-Weierstrass theorem through plotting.

ILO2: Implement the convergence and divergence of sequences and series through visualizations.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Procedural Knowledge			CO1			
Conceptual Knowledge				CO2		
Procedural Knowledge			CO3			
Procedural Knowledge			CO4, CO5			
Procedural Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	Introduction to compartmental model, exponential growth of population, exponential decay model, lake pollution model (case study of Lake Burley Griffin). **List of Practicals** 1. Plotting of second order solution family of differential equation. 2. Plotting of third order solution family of differential equation. 3. Growth model (exponential case only). 4. Decay model (exponential case only). 5. Lake pollution model (with constant/seasonal flow and pollution concentration).	-	00	15x2	30
II (9 Marks)	Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), limited growth of population, limited growth with harvesting. **List of Practicals** 1. Case of single cold pill and a course of coldpills. 2. Limited growth of population (with and without harvesting).	-	00	5x2	10
III (15 Marks)	Predatory-prey model, epidemic model of influenza, battle model. **List of Practicals** 1. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two preyone predator). 2. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers). 3. Battle model (basic battle model, jungle warfare, long range weapons).	-	00	10x2	20

IV (18 Marks)	Plotting recursive sequences, convergence sequences, convergent subsequences, divergent sequences and infinite series 1. Plotting of recursive sequences. 2. Study the convergence of sequences through plotting. 3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. 4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.	-	00	15x2	30
	Total			**45X2**	**90**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Barnes B., Fulford Glenn R., Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and NewYork,2009.
2. Abell Martha L., Braselton James P., Differential Equations with MATHEMATICA, 3rd Ed., Elsevier AcademicPress,2004.

REFERENCE BOOK:

1. Edwards C.H.& Penny D.E., Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	S	M	S	S	S	S
CO2	M	S	S	M	S	S	S	S	S	S
CO3	M	M	S	S	S	M	S	S	S	S
CO4	M	M	M	S	S	M	S	S	S	S
CO5	M	M	M	S	S	S	S	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS
DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Theory of Real Functions**
Course Code	**:**	**MTHC3**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisite: Basic idea of differential calculus

Course Objectives: The course aims to equip the learners with an in-depth knowledge of the theory of real functions. Idea of limit, continuity, uniform continuity, differentiability and their application will be discussed. Rolle's theorem and other mean value theorem will also be introduced. Maclaurin series and Taylor series will be applied to different problems.

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: Evaluate limit of functions.

ILO 1.1: Calculate the limit of a function at a point using algebraic simplification and limit laws.

ILO 1.2: Analyze and solve problems involving limits of functions using epsilon-delta definitions.

CO2: Examine continuity and uniform continuity of functions.

ILO 2.1: Determine the continuity of a function at a point and on an interval using the definition of continuity.

ILO 2.2: Distinguish between continuity and uniform continuity and apply these concepts to various functions.

CO3: Solve problems involving Rolle's theorem.

ILO 3.1: State and prove Rolle's theorem, and apply it to find points where the derivative of a function is zero.

ILO 3.2: Solve problems involving Rolle's theorem to verify the existence of roots within a given interval.

CO4: Apply mean value theorem to inequalities.

ILO 4.1: State and prove the mean value theorem and use it to establish inequalities involving derivatives.

ILO 4.2: Apply the mean value theorem to solve problems related to the behavior of functions on closed intervals.

CO5: Discuss Taylor series with different forms of remainder.

ILO 5.1: Derive the Taylor series expansion of a function and identify different forms of the remainder term.

ILO 5.2: Analyze the error in approximation using Taylor series with different forms of the remainder.

CO6: Apply Maclaurin series and Taylor series to mathematical problems

ILO 6.1: Utilize Maclaurin series to approximate functions and solve related mathematical problems.

ILO 6.2: Apply Taylor series to approximate functions and solve practical problems, considering the remainder term for accuracy.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	X	X	X	CO2	X	X
CONCEPTUAL	X	X	CO3, CO4	X	X	X
PROCEDURAL	CO5	X	CO1, CO6	X	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Limit of a function, Sequential Criterion of limits, Divergence criteria, Statement of Limit theorems & their applications. Statements of the theorems of one sided limits, Infinite Limits and limits at infinity and statements of the related theorems.	06	02	-	08
II (12 Marks)	Continuous Functions and sequential criterion of continuity and discontinuity. Algebra of continuous functions (statements only) & their application to problems, Continuity on an interval, intermediate value theorem, Location Root Theorem, Preservation of interval theorem. Uniform Continuity, Statement of Non uniformity criteria, Uniform Continuity Theorem.	09	03	-	12
III (18 Marks)	Differentiability of a function at a point and in an interval, Caratheodory's Theorem, Algebra of differentiable functions (statements only) and their applications. Relative Extrema, Interior Extremum Theorem. Rolle's Theorem, Mean Value Theorem, Intermediate Value property of derivatives, Darboux's Theorem, Application of Mean Value Theorem to inequalities.	15	05	-	20

IV (18 Marks)	Cauchy's Mean Value Theorem, Taylor's Theorem with Lagrange's form of remainder & Cauchy's form of remainder, Application of Taylor's theorem to convex function. Taylor & Maclaurin series and their applications to simple problems.	15	05	-	20
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Bartle R. G. & Sherbert D. R., Introduction to Real Analysis, 4th Ed., Wiley, 2021
2. Kumar A., Kumaresan S., A Basic Course in Real Analysis, Taylor & Francis Group, 2014.

REFERENCE BOOKS:

1. Fitzpatrick P. M., Advance Calculus, 2nd Edition, AMS Indian Edition, 2010
2. Fischer E., Intermediate Real Analysis, Springer Verlag, 1983.
3. Ross K.A., Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag,2003.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	M	L	S	M	S	S	S
CO2	S	S	L	M	L	S	M	S	S	S
CO3	S	S	L	M	L	S	M	S	S	S
CO4	S	S	L	M	L	S	M	S	S	S
CO5	S	S	L	M	L	S	M	S	S	S
CO6	S	S	L	M	L	S	M	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Group Theory I**
Course Code	**:**	**MTHC4**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisites: Set theory and basic knowledge of Arithmetic.

Course Objectives: The course intends to introduce to the learners the abstract structure called group. Besides various examples of group the learners will deal with different groups like abelian group, cyclic group, normal subgroup, quotient group. Important theorems like Lagrange's theorem, Caley's theorem, isomorphism theorems will also be discussed at length. Construction of new group from existing ones, viz., quotient group, direct product of groups is an important objective of this course.

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: Identify groups like Klein 4-group, symmetric group, Dihedral group.

ILO 1.1: Recognize and describe the structure and properties of the Klein 4-group.

ILO 1.2: Identify and analyze the elements and properties of symmetric and dihedral groups.

CO2: State Lagrange's theorem, isomorphism theorems, fundamental theorem of Abelian groups.

ILO 2.1: State and explain Lagrange's theorem and its implications in group theory.

ILO 2.2: Describe the isomorphism theorems and the fundamental theorem of Abelian groups, providing examples of each.

CO3: Analyze permutation group.

ILO 3.1: Describe the structure and properties of permutation groups, including cycle notation and transpositions.

ILO 3.2: Solve problems involving the properties and operations of permutation groups.

CO4: Apply Lagrange's theorem to examine divisibility of a group by a subgroup.

ILO 4.1: Use Lagrange's theorem to determine the possible orders of subgroups within a finite group.

ILO 4.2: Apply Lagrange's theorem to analyze and solve problems involving the divisibility of the order of a group by the order of its subgroups.

CO5: Construct quotient group from a group and a normal subgroup.

ILO 5.1: Define and construct quotient groups given a group and a normal subgroup.

ILO 5.2: Demonstrate the process of forming quotient groups and solve related problems.

CO6: Solve problems applying properties of isomorphism.

ILO 6.1: Identify and prove isomorphisms between groups using the properties of group homomorphisms.

ILO 6.2: Solve problems involving group isomorphisms, including determining if two groups are isomorphic.

CO7: Explain direct product of groups.

ILO 7.1: Define and construct the direct product of two groups, explaining the resulting group's structure and properties.

ILO 7.2: Solve problems involving the direct product of groups and analyze its properties in various contexts.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO1, CO2	X	X	X	X	X
CONCEPTUAL	X	X	CO6	CO3	X	CO5
PROCEDURAL	X	CO4, CO7	X	X	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (11 Marks)	Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups.	09	03	-	12

II (11 Marks)	Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.	03	02	-	06
III (16 Marks)	Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.	12	04	-	16
Unit IV (11 Marks)	External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.	09	03		12
Unit V (11 Marks)	Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.	09	03		12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Describe various group structures onsets.
- Identify the group structures present in different branches of sciences.

TEXTBOOKS:

1. Gallian J.A., Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, NewDelhi,1999.
2. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

REFERENCE BOOKS:

1. Dummit D.S. & Foote R. M., Abstract Algebra 3rd Ed., Wiley, 2011.
2. Rotman J. J., An Introduction to the Theory of Groups, 4th Ed., Springer Verlag,1995.
3. Herstein, I.N., Topics in Algebra, Wiley, India, 2006.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	M	L	S	M	S	S	S
CO2	S	S	L	M	L	S	L	M	S	S
CO3	S	S	M	M	L	S	L	S	S	S
CO4	S	S	M	M	L	S	L	S	S	S
CO5	S	S	M	M	L	S	L	S	S	S
CO6	S	S	M	M	L	S	M	S	S	S
CO7	S	S	M	M	L	S	M	S	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Differential Equations**
Course Code	**:**	**MINMTH3**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Differential Equation focuses on the various methods for solving ODE and PDE.

COURSE OBJECTIVE:

The objectives of the course are

i. To introduce the concept of differential equations, mathematical modelling and their application
ii. To explain the solution techniques of ODE and PDE.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: understand exact differential equation and solve them

ILO 1.1: Construction of integrating factor.

ILO 1.2: Determine the solution of exact differential equations.

CO2: Explain the basic theory of linear differential equation, Wronskian and its properties.

ILO 2.1: Use of Wronskian in solving the differential equation

ILO 2.2: Discuss methods for solving higher order differential equations.

ILO 2.3: Solve the differential equations of first order and higher degree.

CO3: distinguish various techniques for solving linear homogeneous and non-homogeneous differential equations

ILO 3.1: discuss CF and PI in solving differential equations

ILO 3.2: Explain method of variation of parameter in solving differential equation and apply it.

ILO 3.3: give the significance of total differential equation

CO 4: introduce PDE and understand basic techniques of solving PDE

ILO 4.1: Construction of PDE

ILO 4.2: Differentiate various techniques of solving PDE

CO 5: Classify second order PDE

ILO 5.1: techniques of classification of PDE

ILO 5.2: Examples of elliptic, parabolic and hyperbolic PDE.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						CO1, CO4
Conceptual Knowledge	CO5	CO4	CO3			
Procedural Knowledge						
Metacognitive Knowledge		CO2				

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	First order exact differential equations. Integrating factors, rules to find an integrating factor.	09	03	-	12
II (15 Marks)	First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.	12	04	-	16
III (12 Marks)	Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.	09	03	-	12
IV (12 Marks)	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	09	03		12
V (9 Marks)	Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.	06	02		12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Ross S. L., Differential Equations, 3rd Ed., John Wiley and Sons,1984.

2. Boyce, W. E. and DiPrima, R. C., Elementary Differential Equation and Boundary Value Problems, 7th Edition, John Wiley & Sons (Asia), 2001.

REFERENCE BOOKS:

1. Sneddon I.N., Elements of Partial Differential Equations, McGraw-Hill, International Edition, 1967.
2. Raisinghania M.D., Ordinary and Partial Differential Equations, 19thEd., S. Chand and Company, 2020.

Mapping of Course Outcome to Program Outcome

CO/PO	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	S	S	S
CO2	S	S	M	M	M	M	M	S	S	S
CO3	S	S	M	M	M	M	M	S	S	S
CO4	S	S	M	M	M	M	M	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Mathematical Finance**
Course Code	**:**	**GECMTH3A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Objective:

The main motive of this course is to give students a basic introduction to finance and the applications of mathematics to it. The course focuses on the mathematical properties and relations between concepts of financial markets in investment and other economic activities. In the era of mathematical modelling being used in understanding stock market behaviour and large dynamic data, this introductory course in Mathematics of finance is well placed to prepare students interested in choosing a career in the field of mathematical finance.

Prerequisites:

(a) Basic Mathematical skills taught upto the 10+2 level.

Course Outcomes (COs):

Students will be able to

CO 1**:** Apply basic mathematical tools (functions, equations, inequalities) to construct and analyze economic models of markets including Supply and demand relationships, Market equilibrium conditions and the impact of government interventions (e.g., excise taxes) on market. outcomes.

ILO 1.1: Form economic models of markets using functions, equations, and inequalities.

ILO1.2: Calculate the future value of investments considering interest rates and compounding intervals.

ILO 1.3: Explain the impact of different compounding frequencies on investment growth.

CO 2: Analyze the stability of market equilibrium using the Cobweb model and its economic interpretations.

ILO 2.1: Identify the key factors influencing the stability of market equilibrium in the Cobweb model (e.g., slope of supply and demand curves).

ILO 2.2: Explain the economic interpretation of the Cobweb model's results, including its implications for real-world markets.

CO3: Apply the concept of the derivative to analyze and solve economic problems related to **Demand and Elasticity,** Production and Cost, **Market Structures, Firm Efficiency and Growth.**

ILO 3.1: Define ke**y** economic concepts like elasticity of demand, marginal cost, marginal revenue, and economic profit.

ILO 3.2: Utilize derivatives to calculate elasticity coefficients and interpret them to understand consumer behaviour.

ILO 3.3: Apply derivative analysis to identify production levels that maximize profit for firms.

ILO 3.4: Analyze the impact of market structures on pricing and output decisions using derivative tools.

ILO 3.5: Determine startup and breakeven points for firms using cost functions and derivative analysis.

CO4: Apply fundamental mathematical concepts and financial theories to analyze investment opportunities, make informed investment decisions, and evaluate financial instruments.

ILO 4.1: Utilize the time value of money concepts (present value, future value, internal rate of return) to assess the cash flow implications of various investment options.

ILO 4.2: Differentiate between pricing, hedging, and pure investment strategies and apply appropriate techniques for each, considering risk aversion and market conditions.

ILO 4.3: Demonstrate the characteristics, and risks associated with different investment instruments in the market for future cash, such as savings deposits, money market instruments, and various types of bonds, using metrics like yield and duration.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1,CO2		CO1, CO2			
Conceptual Knowledge		CO3	CO1, CO2	CO2, CO3		
Procedural Knowledge		CO3, CO4	CO1, CO3			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Mathematical models in economics: Introduction, A model of the market, Market equilibrium, Excise tax. The elements	06	03	-	09

	of finance: Interest and capital growth, Income generation, The Interval of compounding.				
II (12 Marks)	The Cobweb model: How stable is market equilibrium? An example, The general linear case, Economic interpretation.	06	03	-	09
III (12 Marks)	The derivative in economics: Elasticity of demand, profit maximization, Competition versus monopoly, The efficient small firm, startup and breakeven points.	06	03	-	09
IV (12 Marks)	Introduction to investment Science: Cash flow, investment and markets, comparison principle, arbitrage, risk aversion. Typical investment problems: Pricing, Hedging, pure investment.	06	03		09
V (12 Marks)	Basic theory of interest: Principal and interest, compound interest, compounding at various intervals, continuous compounding, present value, present and future values of streams, internal rate of return, Evaluation criteria. The market for future cash: Savings deposits, money market instruments, various bonds, Bond details, Yield, duration, Macaulay duration.	06	03		09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- apply models to financial mathematics/industries
- ability to use mathematical tools to market economy.

TEXTBOOKS:

1. Anthony M. & Biggs N., Mathematics for Economics and Finance: Methods and Modelling, Cambridge University Press: Reprinted 2009.

2. Chiang A. C. & Wainwright K., Fundamental Methods of Mathematical Economics, 4th Ed., McGraw Hill Education, 2017.

REFERENCE BOOKS:

1. Luenberger David G., Investment Science, Stanford University: 1998.
2. Ross S., An elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	M	S	S	S
CO2	S	S	M	S	M	S	S	M	M	S
CO3	S	M	M	S	M	S	M	S	S	S
CO4	M	S	S	M	M	S	M	M	M	M

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Combinatorial Mathematics**
Course Code	**:**	**GECMTH3B**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Combinatorial Mathematics course covers a range of fundamental concepts and techniques used in combinatorics, as well as their applications in various fields.

Prerequisites:

- Basics of Set Theory

Course Objectives:

1. To develop problem-solving skills and logical thinking required for tackling combinatorial problems.
2. To enhance the ability to construct rigorous mathematical proofs, including combinatorial proofs and inductive reasoning.
3. To equip with a toolkit of methods and techniques that are widely applicable in various scientific and engineering disciplines.

Course Outcomes (COs):

On successful completion of the course, the students will be able to

CO1: Apply basic counting principles such as the rule of sum, rule of product, principles of inclusion-exclusion, permutations, and combinations.

ILO 1.1: Define and explain key combinatorial concepts, including sets, permutations, and combinations.

ILO 1.2: Apply basic counting principles and principles of inclusion-exclusion

CO2: Investigate properties and applications of combinatorial structures such as partitions, permutations, and derangements. Solve problems involving the binomial theorem and Pascal's triangle.

ILO 2.1: Calculate permutations and combinations in various contexts, including those with repetitions and restrictions.

ILO 2.2: Write detailed solutions and proofs for combinatorial problems, demonstrating a thorough understanding of the concepts.

CO3: Solve problems using recurrence relations and generating functions.

ILO 3.1: Formulate and solve problems involving recurrence relations.

ILO 3.2: Utilize generating functions to approach and solve counting problems.

CO4: Apply advanced topics like Pólya's enumeration theorem and Burnside's lemma.

ILO 4.1: Understand and apply advanced topics such as Pólya's Enumeration Theorem and Burnside's Lemma to solve counting problems involving symmetries.

ILO 4.2: Use combinatorial reasoning to ensure the correctness and efficiency of solutions.

CO5: Construct combinatorial designs such as balanced incomplete block designs (BIBD) and Latin squares.

ILO 5.1: Understand and apply concepts of combinatorial design, including block designs and Latin squares.

ILO 5.2: Develop and employ strategies for solving complex combinatorial problems

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		
Procedural Knowledge			CO1, CO2	CO3	CO4	
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (12 Marks)	Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers	06	03	-	09
II (12 Marks)	Principle of Inclusion and Exclusion, Derangements, Inversion formulae	06	03	-	09

III (12 Marks)	Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.	06	03	-	09
IV (12 Marks)	Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.	06	03	-	09
V (12 Marks)	Integer partitions, Systems of distinct representatives. Polya theory of counting: Necklace problem and Burnside's lemma, Polya's theorems and their immediate applications	06	03	-	09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - 2**0 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Use combinatorial approach in solving algebraic problems
- Explain counting principles.

TEXTBOOK:

1. Balakrishnan V. K., Introductory Discrete Mathematics, Dover Publications Inc., 2000.

REFERENCE BOOKS:

1. Lint J.H. van & Wilson R.M., A Course in Combinatorics, 2nd Ed., Cambridge University Press,2001.
2. Krishnamurthy V., Combinatorics, Theory and Applications, East-West Press 2008.
3. Brualdi R.A., Introductory Combinatorics, 5th Ed., Pearson Education Inc., 2009.
4. Cameron P. J., Combinatorics, Topics, Techniques, Algorithms, Cambridge University Press, 1995.

Mapping of Course Outcomes to Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	L	M	S	M	S	M
CO2	S	S	S	S	L	M	M	S	S	M
CO3	M	S	S	M	L	S	M	S	M	S
CO4	M	M	S	S	L	S	S	S	S	S
CO5	S	M	S	S	L	S	S	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Mathematical Logic**
Course Code	**:**	**SEC315**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Mathematical Logic aims to provide students with a solid foundation in the principles and applications of formal logic. It covers key topics such as propositional logic, predicate logic, and the formalization of logical arguments. The course also includes an introduction to set theory and its role in logic, as well as an examination of relations, partitionsand partial ordered relation.

Course Objectives:

- To develop the ability to apply logical reasoning to solve complex problems inmathematics and computer science, enhancing their analytical and critical thinking skills through exercises and real-world applications.
- To be proficient in formal logical reasoning and prepared to engage in further study or professional work that involves mathematical logic.

Course Outcomes (COs):
On successful completion of the course, the students will be able to

CO1: Understand Fundamental Concepts

ILO 1.1: Define and explain key concepts in mathematical logic, including propositions, logical connectives, truth tables, and logical equivalence.

ILO 1.2: Understand and explain the structure and elements of formal proofs, including axioms, theorems, lemmas, and corollaries.

CO2: Apply Propositional Logic

ILO 2.1: Construct and analyze truth tables for various logical statements.

ILO 2.2: Apply rules of inference and logical equivalences to simplify and manipulate logical expressions.

ILO 2.3: Use propositional logic to prove the validity of arguments.

CO3: Understand and Apply Predicate Logic

ILO 3.1: Define and explain the elements of predicate logic, including predicates, quantifiers, and domains of discourse.

ILO 3.2: Translate statements between natural language and predicate logic notation.

ILO 3.3: Apply rules of inference in predicate logic to prove the validity of arguments.

CO4: Analyze Logical Systems and Proof Techniques

ILO 4.1: Understand and apply various proof techniques, including direct proof, proof by contradiction, and proof by induction.

ILO 4.2: Analyze and construct formal proofs in both propositional and predicate logic.

ILO 4.3: Understand the concepts of consistency, completeness, and soundness in logical systems.

CO5: Develop Problem-Solving Strategies

ILO 5.1: Develop and implement strategies for solving complex problems in mathematical logic.

ILO 5.2: Use logical reasoning to analyze and solve problems in various mathematical contexts.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO4	CO5		
Procedural Knowledge			CO1, CO2	CO3	CO4	
Metacognitive Knowledge						CO5

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse	10	05	-	15

	propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.				
II (15 Marks)	Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set.	08	04	-	12
III (12 Marks)	Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.	04	02	-	06
IV (15 Marks)	Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-array relations.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Analyze the truth and falsity of a logical statement.
- Differentiate between a logical statement and an ordinary statement.
- Define and describe various properties of sets.

TEXTBOOK:

1. Kumar A., Kumaresan S., Sarma B. K., A Foundation Course in Mathematics, Alpha Science International, 2017.

REFERENCE BOOKS:

1. Srivastava S.M., A Course on Mathematical Logic, Springer, 2012
2. Halmos P.R., Naive Set Theory, Springer,1974.
3. Kamke E., Theory of Sets, Dover Publishers,1950.
4. Grimaldi R.P., Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.

Mapping of Course Outcomes to Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	L	M	S	M	M	M
CO2	S	S	S	S	L	M	M	S	S	M
CO3	M	S	M	M	L	S	M	S	S	M
CO4	M	M	S	S	L	S	S	S	S	S
CO5	S	M	S	S	L	S	S	S	S	S

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Numerical Methods**
Course Code	**:**	**MTHC5**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=0, P=1)**
Distribution of Marks	**:**	**45 (End Sem) +15 (Practical) + 40 (In-Sem)**

Course Description:

This course introduces numerical methods for solving mathematical problems that arise in engineering and science. Topics include root-finding, interpolation, numerical differentiation and integration, solutions to linear and nonlinear systems, and numerical solutions of differential equations. Emphasis is placed on algorithm development, error analysis, and practical implementation using computational tools.

Prerequisites:
Basic knowledge of calculus, linear algebra, and differential equations.

Course Objectives:

- To Understand fundamental numerical techniques and their applications.
- To Develop algorithms for solving mathematical problems computationally.
- To Analyze the accuracy, stability, and efficiency of numerical methods.
- To Implement numerical algorithms using programming tools.
- To Apply numerical techniques to scientific problems.

Course Outcome: On successful completion of the course, the students will be able to

CO1: Understand and analyze the concepts of numerical errors, convergence, and root-finding methods.
ILO1.1: Explain types of numerical errors, their sources, and impact on computations.
ILO1.2: Apply Bisection, Newton-Raphson, and Secant methods to solve nonlinear equations.
ILO1.3: Analyze the rate of convergence of different root-finding techniques.

CO2: Solve linear system of equations using direct and iterative methods.
ILO2.1: Implement Gaussian Elimination and Gauss-Jordan methods for system solutions.
ILO2.2: Apply Gauss-Jacobi and Gauss-Seidel methods for iterative solutions.
ILO2.3: Evaluate the convergence criteria for iterative methods.

CO3: Use interpolation techniques for estimating unknown values.
ILO3.1: Apply Lagrange and Newton's interpolation methods.
ILO3.2: Use finite difference operators for function approximation.

ILO3.3: Implement Newton-Gregory forward and backward difference interpolation methods.

CO4: Perform numerical integration and solve ordinary differential equations numerically.
ILO4.1: Apply Trapezoidal, Simpson's, and other numerical integration methods.
ILO4.2: Analyze the accuracy of composite numerical integration techniques.
ILO4.3: Solve first-order ODEs using Euler's and Runge-Kutta methods.

CO5: Develop computational algorithms to implement numerical techniques.
ILO5.1: Write programs for root-finding, interpolation, and numerical integration.
ILO5.2: Implement iterative methods for solving linear equations using software tools.
ILO5.3: Analyze the accuracy and efficiency of implemented numerical methods through practical applications.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge		CO1				
Conceptual Knowledge			CO1; CO2; CO4			CO5
Procedural Knowledge			CO3	CO1; CO4; CO5	CO2	
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (9 Marks)	Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.	09	00	00	09
II (9 Marks)	System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.	09	00	00	09
III (9 Marks)	Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. NEWTON Gregory forward and backward difference interpolation.	09	00	00	09
IV (9 Marks)	Numerical Integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.	09	00	00	09
V (9 Marks)	Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.	09	00	00	09
VI (15 Marks)	**List of Practicals (using any software)** (i) Calculate the sum	-	-	30	30

	1/1 + 1/2 + 1/3 + 1/4 + ---+ 1/N. (ii) To find the absolute value of an integer. (iii) Enter 100 integers into an array and sort them in an ascending order. (iv) Bisection Method. (v) Newton Raphson Method. (vi) Secant Method. (vii) Regula Falsi Method. (viii) LU decomposition Method. (ix) Gauss-Jacobi Method. (x) Gauss-Siedel Method. (xi) Lagrange Interpolation or Newton Interpolation. (xii) Simpson's rule. Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.				
	Total	**45**	**00**	**30**	**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Jain M. K., Iyengar S. R. K. and Jain R. K., Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
2. Atkinson K., An Introduction to Numerical Analysis (2nd Edition), Wiley Publications, 1978.
3. Bradie B., A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

REFERENCE BOOKS:

1. Gerald C. F. and Wheatley P.O., Applied Numerical Analysis, Pearson Education, India, 2008.
2. Ascher U.M. and Greif C., A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
3. Mathews J. H. and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	M	S	S
CO2	S	S	S	M	S	M	M	M	S	S
CO3	S	S	S	M	S	M	M	M	S	S
CO4	S	S	S	M	S	M	M	M	S	S
CO5	S	S	S	M	S	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Riemann Integration & Series of Functions**
Course Code	**:**	**MTHC6**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an in-depth study of Riemann integration and the convergence of function series. Topics include Riemann integrability, fundamental theorems of calculus, improper integrals, sequences and series of functions, uniform convergence, power series, and applications to Fourier series. Emphasis is placed on rigorous proofs and theoretical understanding.

Pre-requisite: Real Analysis

Course Objective: This course aims to provide a comprehensive understanding of Riemann integration and its foundational properties, including conditions for integrability, improper integrals, and the Fundamental Theorem of Calculus. Students will explore convergence criteria for sequences and series of functions, focusing on uniform convergence and its implications for continuity, differentiability, and integrability. Additionally, the course introduces the theory of power series, including their convergence, differentiation, and integration, and concludes with applications of classical theorems such as Abel's Theorem and the Weierstrass Approximation Theorem.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

CO1: Understand and apply the concepts of Riemann integration and its fundamental properties.

- **ILO1.1:** Define Riemann integration and interpret its conditions of integrability.
- **ILO1.2:** Analyze and compute upper and lower sums to evaluate Riemann integrals.
- **ILO1.**3: Prove the integrability of monotone and continuous functions.
- **ILO1.4:** Apply the Fundamental Theorem of Calculus and the Intermediate Value Theorem for integrals.

CO2: Evaluate improper integrals and understand their convergence, including special functions.

- **ILO2.1:** Identify and analyze the convergence of improper integrals using appropriate techniques.
- **ILO2.2:** Demonstrate a comprehensive understanding of Beta and Gamma functions and their convergence.

CO3: Develop a strong foundation in the concepts of pointwise and uniform convergence of function sequences and series.

- **ILO3.1:** Differentiate between pointwise and uniform convergence and evaluate convergence using appropriate tests.
- **ILO3.2:** Apply theorems on the continuity, differentiability, and integrability of the limit functions of sequences and series.
- **ILO3.3:** Use the Cauchy criterion and Weierstrass M-Test to analyze the uniform convergence of series.

CO4: Explore topics in power series, and their applications in mathematical analysis.

- **ILO4.1:** Define and compute the radius of convergence using the Cauchy-Hadamard Theorem.
- **ILO4.2:** Perform differentiation and integration of power series and apply Abel's Theorem.
- **ILO4.3:** Demonstrate the Weierstrass Approximation Theorem and its applications in approximating functions.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL	**CO8**	**CO2**	**X**	**X**	**CO6**	**X**
CONCEPTUAL	**C10**	**X**	**CO3, CO11, CO12**	**X**	**CO5**	**X**
PROCEDURAL	**X**	**CO1, CO4**	**CO9**	**X**	**CO7**	**X**
METACOGNITIVE	**X**	**X**	**X**	**X**	**X**	**X**

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**

I **(18 Marks)**	Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Calculus.	18	06	-	24
II **(12 Marks)**	Improper integrals; Convergence of Beta and Gamma functions.	06	02	-	08
III **(18 Marks)**	Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.	15	05	-	20
IV **(12 Marks)**	Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.	06	02	-	08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Bartle R. and Sherbert D. R., Introduction to Real Analysis, John Wiley and Sons, 2003.

2. Kumar A. & Kumaresan S., A Basic Course in Analysis, CRC Press, 2014.

REFERENCE BOOKS:

1. Ghorpade S. R. and Limaye B. V., A Course in Calculus and Real Analysis, Springer, 2006.
2. Ross K. A., Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
3. Denlinger C. G., Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	L	L	M	L	M	S	S
CO2	S	S	L	L	L	S	M	S	S	S
CO3	S	S	L	L	L	M	L	M	S	S
CO4	S	S	L	L	L	M	L	M	S	S
CO5	S	S	L	L	L	M	M	S	S	S
CO6	S	S	L	L	L	M	M	M	S	S
CO7	S	S	L	L	L	M	L	M	S	S
CO8	S	S	L	L	L	M	L	M	S	S
CO9	S	S	L	L	L	M	L	M	M	S
CO10	S	S	L	L	L	S	M	M	S	S
CO11	S	S	L	L	L	S	M	S	S	S
CO12	S	S	L	M	L	S	S	S	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Ring Theory and Linear Algebra I**
Course Code	**:**	**MTHC7**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course introduces fundamental concepts in Ring Theory and Linear Algebra. Topics include rings, ideals, homomorphisms, quotient rings, polynomial rings, vector spaces, linear transformations, eigenvalues, eigenvectors, and inner product spaces. Emphasis is placed on theoretical foundations and problem-solving techniques, preparing students for advanced studies in algebra and its applications.

Prerequisite:

- Set theory, Group, subgroup and its properties
- Algebra, Matrices
- Co-ordinates

Course Objective: The objective of this course is to provide a comprehensive understanding of ring theory, covering concepts such as rings, subrings, integral domains, fields, ideals, factor rings, and prime/maximal ideals. It also focuses on ring homomorphisms, the First, Second, and Third Isomorphism Theorems, and the field of quotients. Additionally, the course explores linear transformations, including null space, range, rank, and matrix representation, along with isomorphisms, invertibility, and the change of coordinate matrix, equipping students with essential skills to apply these concepts in algebraic contexts.

Course outcomes:

After completing the course the students will be able to

CO1: Understand and apply the fundamental concepts of rings, subrings, integral domains, and fields.

LO1.1: Construct the algebraic structures using various binary operations

LO1.2: Utilize the notion of unit and unity element to categorize algebraic structures

CO2: Demonstrate an understanding of the properties of rings and their significance in algebraic structures.

LO2.1: Analyze an algebraic structure with the help of properties of ring, subring and various associated structures

LO2.2: Identify and demonstrate the properties of integral domains and fields, and explain their differences from general rings

LO3.3: Calculate the characteristic of a ring and understand its influence on the ring's structure and operations.

CO3: Analyze the concept of ideals, including prime and maximal ideals, and factor rings

LO3.1: Understand and prove the properties of ideals, including the ideal generated by a subset of a ring, and identify the structure of factor rings.

LO3.2: Explore and analyze operations on ideals such as intersection, sum, and product, and understand their applications in ring theory.

LO3.3: Define and work with factor rings (quotient rings), and understand how they are formed by partitioning a ring using ideals. Explore their significance in simplifying ring structures.

CO4: Understand and apply the concept of ring homomorphisms, their properties, and their role in the structural study of rings.

LO4.1: Define and provide examples of ring homomorphisms and analyze their properties.

LO4.2: Understand and apply the First, Second, and Third Isomorphism Theorems for rings.

CO5**:** Apply isomorphism theorems for rings and the construction of the field of quotients to solve algebraic problems.

LO5.1: Demonstrate the process of constructing the field of quotients for an integral domain.

LO5.2: Solve problems involving ring homomorphisms, quotient rings, and isomorphism theorems. 7

CO6: Understand the fundamental concepts of vector spaces, subspaces, quotient spaces, and their algebraic structures.

LO6.1: Define and provide examples of vector spaces, subspaces, and their algebraic operations.

LO6.2: Understand the concepts of linear span, linear combinations, and linear independence of vectors.

CO7: Analyze and apply concepts of linear dependence, basis, and dimension to solve problems related to vector spaces and their subspaces.

LO7.1: Determine the basis and dimension of vector spaces and subspaces.

LO7.2: Construct and analyze quotient spaces and explore their relationship with subspaces.

CO8: Understand and analyze the fundamental concepts of linear transformations, their properties, and their representation using matrices.

LO8.1: Define and analyze linear transformations, their null space, range, rank, and nullity.

LO8.2: Represent linear transformations using matrices and perform operations on them.

CO9: Apply theorems on isomorphisms, rank-nullity, and coordinate changes to analyze and solve problems in linear algebra.

LO9.1: Understand and apply isomorphism theorems and conditions for invertibility in linear transformations.

LO9.2: Compute and interpret the change of coordinate matrix in different bases.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL						CO1
CONCEPTUAL		CO1; CO4; CO8;				CO7
PROCEDURAL		CO6; CO9	CO1; CO5	CO2; CO3; CO4; CO7; CO8		
METACOGNITIVE			CO9			

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Definition and examples of rings, Properties of rings, Subrings, Integral domains and fields, characteristic of a ring. Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.	09	03	-	12
II (18 Marks)	Ring homomorphisms, Properties of ring homomorphisms, First, Second and Third Isomorphism theorems for rings, The Field of quotients.	12	04	-	16
III (12 Marks)	Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.	12	04	-	16
IV (18 Marks)	Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations. Isomorphisms, Isomorphism theorems, Invertibility and the change of coordinate matrix.	12	04	-	16
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**

- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Gallian J. A., Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
2. Kumaresan S., Linear Algebra- A Geometric Approach, Prentice Hall ofIndia,1999.
3. Friedberg S. H., Insel A. J., Spence L. E., Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

REFERENCE BOOKS:

1. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. Strang G., Linear Algebra and its Applications, Thomson, 2007.
3. Hoffman K., Kunze R. A., Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4. Artin M., Abstract Algebra, 2nd Ed., Pearson, 2011.
5. Lang S., Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Wallace D. A. R., Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S
CO7	S	S	M	M	L	M	M	M	S	S
CO8	S	S	M	M	L	M	M	M	S	S
CO9	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**PDE and Systems of ODE**
Course Code	**:**	**MTHC8**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course covers fundamental concepts of partial differential equations (PDEs) and systems of ordinary differential equations (ODEs). Topics include classification of PDEs, solution methods such as separation of variables and Fourier series, and applications in physics and engineering. For ODE systems, phase plane analysis, stability, and numerical methods are explored. The course emphasizes analytical and computational techniques for solving differential equations.

Prerequisite: Differential Equations, Linear Algebra.

Course Objectives:

- To Solve first- and second-order PDEs using analytical methods.
- To Analyze systems of ODEs using phase portraits and stability theory.
- To Apply Fourier series and numerical techniques to solve PDEs.
- To Model physical systems using PDEs and ODE systems.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: Understand and apply the fundamental concepts of first-order partial differential equations and solve them using appropriate methods.

ILO1.1: Classify and construct first-order partial differential equations and interpret their geometrical significance.

ILO1.2: Apply the method of characteristics to solve quasi-linear equations.

ILO1.3: Utilize Charpit's and Jacobi's methods for solving nonlinear partial differential equations.

CO2: Apply separation of variables to solve first-order partial differential equations.
ILOs:

ILO2.1: Derive and identify the canonical forms of first-order linear equations.

ILO2.2: Implement the method of separation of variables for solving first-order PDEs.

ILO2.3: Analyze and formulate solutions to mathematical problems involving first-order PDEs.

CO3: Classify and solve second-order linear partial differential equations.

ILO3.1: Differentiate between hyperbolic, parabolic, and elliptic equations.

ILO3.2: Derive and solve the heat, wave, and Laplace equations.

ILO3.3: Transform second-order linear equations into canonical forms.

CO4: Apply analytical methods to solve second-order PDEs arising in physical models.

ILO4.1: Formulate mathematical models using heat, wave, and Laplace equations.

ILO4.2: Solve second-order PDEs using appropriate analytical techniques.

ILO4.3: Interpret the physical significance of solutions.

CO5: Solve boundary value problems using the method of separation of variables.

ILO5.1: Develop solutions for the vibrating string problem using separation of variables.

ILO5.2: Apply the separation of variables technique to the heat conduction problem.

CO6: Analyze and implement numerical approaches to solving PDEs.

ILO6.1 Evaluate different numerical techniques for solving PDEs.

ILO6.2: Compare analytical and numerical methods for solving PDE-related problems.

CO7: Solve systems of linear differential equations using analytical and numerical techniques.

ILO7.1: Classify different types of linear differential systems and their properties.

ILO7.2: Apply the operator method to solve linear systems with constant coefficients.

ILO7.3: Develop solutions for homogeneous linear systems using mathematical techniques.

CO8: Implement numerical methods to approximate solutions of differential equations.

ILO8.1: Apply the method of successive approximations to solve differential equations.

ILO8.2: Implement Euler and modified Euler methods for numerical solutions.

ILO8.3: Use the Runge-Kutta method up to fourth-order approximation for solving ODEs.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL						
CONCEPTUAL		CO1; CO3; CO7	CO2		CO6	CO5; CO7
PROCEDURAL			CO1; CO3; CO5; CO7	CO2;CO6		
METACOGNITIVE			CO4; CO8			

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Non-linear partial differential equations, Charpit's method & Jacobi's method Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.	12	04	-	16
II (15 Marks)	Classifications of second order linear equations as hyperbolic, parabolic or elliptic. Derivations of Heat equation, Wave equation and Laplace equation and their solutions Reduction of second order Linear Equations to canonical forms.	12	04	-	16
III (9 Marks)	Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem	09	03	-	12
IV (18 Marks)	Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method upto fourth order approximation	12	04	-	16
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Ross S. L., Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
2. Myint-U T. and Debnath L., Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.

REFERENCE BOOKS:

1. Sneddon I. N., Elements of Partial Differential Equations, Dover Publications, 2006.
2. W. E. Boyce W. E., DiPrima R. C., Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley, 2009.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S
CO7	S	S	M	M	L	M	M	M	S	S
CO8	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Algebra**
Course Code	**:**	**MINMTH4**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Objectives: The objectives of this Course are to -

- Describe various algebraic structures on sets.
- Identify the algebraic structures present in different branches of Sciences.

Prerequisite:

- Set theory,
- Number system, polynomial
- Matrices

Course Objective: The objective of this course is to introduce students to the fundamental concepts of group theory and ring theory. It aims to develop an understanding of groups, subgroups, cosets, normal subgroups, quotient groups, and key theorems such as Lagrange's theorem. The course also covers rings, subrings, ideals, integral domains, and fields, with a focus on examples from number systems, matrices, and polynomial rings. By the end of the course, students will be able to apply these algebraic structures to solve problems in abstract algebra and related fields.

Course outcome: After completion of this course, students will be able to

CO1: Understand and analyze the fundamental concepts of groups and their examples.

ILO1.1: Define groups and differentiate between abelian and non-abelian groups.
ILO1.2: Explore examples of groups, such as Zn,$U(n)$,$GL(n,R)$ quaternion groups.
ILO1.3: Understand the circle group and groups of symmetries (e.g., triangles, rectangles, squares).

CO2: Analyze the structure of subgroups and cyclic subgroups.

ILO2.1: Define and identify subgroups, cyclic subgroups, and the center of a group.
ILO2.2: Understand the concept of order of an element and how to determine it.
ILO2.3: Explain subgroups generated by subsets and the commutator subgroup of a group.

CO3: Apply Lagrange's theorem, cosets, and index of a subgroup.

ILO3.1: Define cosets and index of a subgroup and analyze their properties.
ILO3.2: State and prove Lagrange's theorem, and apply it to compute subgroup orders.
ILO3.3: Understand the implications of Lagrange's theorem on group order and structure.

CO4: Examine normal subgroups and quotient groups.

ILO4.1: Define and identify normal subgroups with relevant examples.
ILO4.2: Understand the concept of quotient groups and their significance in group theory.
ILO4.3: Explore different characterizations of normal subgroups and their applications.

CO5: Understand and analyze the basic structure of rings and their properties.

ILO5.1: Define rings, differentiate between commutative and non-commutative rings, and provide examples.
ILO5.2: Identify examples of rings from number systems Zn, real quaternions, matrices, and polynomial rings.
ILO5.3: Explain the concepts of subrings and ideals with relevant examples.

CO6: Explore integral domains, fields, and their relationships with rings.

ILO6.1: Define integral domains and fields and explore their properties.
ILO6.2: Identify examples of fields such as Zp,Q,R,C
ILO6.3: Analyze the relationship between rings, integral domains, and fields, and apply these concepts to abstract algebra problems.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL						
CONCEPTUAL		**CO1; CO2; CO3; CO4**		**CO5**		
PROCEDURAL		**CO5; CO6**	**CO3**	**CO1; CO2; CO4**		
METACOGNITIVE				**CO6**		

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers modulo n under addition modulo n and the group U(n) of units under multiplication modulo n. Complex roots of unity, circle group, the general linear group $GL(n,R)$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, symmetric groups, Group of quaternions.	12	04	-	16

II (12 Marks)	Subgroups, cyclic subgroups, order of an element, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Cosets, Index of subgroup.	09	03	-	12
III (12 Marks)	Lagrange's theorem, Normal subgroups: their definition, examples, and characterizations, Quotient groups.	09	03		12
IV (18 Marks)	Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: Z_p, Q, R, and C.	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Describe the fundamental concept of Groups, Subgroups and related theorems.
- Apply the fundamental concept of Rings, Fields, Subrings, Integral domains.

TEXTBOOKS:

1. Gallian J. A., Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.
2. Musili C., Introduction to Rings and Modules, Narosa Publishing House, 2nd Edition, 1997.

REFERENCE BOOK:

1. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Multi-Variate Calculus**
Course Code	**:**	**MTHC9**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an introduction to multivariable calculus, covering the fundamental concepts and techniques used to analyze functions of multiple variables. Topics include limits, continuity, and differentiability of functions of two variables, partial derivatives, gradient vectors, and optimization methods. The course also explores multiple integrals in different coordinate systems, vector fields, and important integral theorems such as Green's, Stokes', and the Divergence theorem. Emphasis is placed on both theoretical understanding and practical applications in physics and engineering.

Prerequisites

- Limits, continuity, and differentiation of single-variable functions.
- Integration techniques, including substitution and integration by parts.
- Parametric equations and polar coordinates.
- Basic understanding of vectors and their properties.

Course Objectives:

1. To Apply differentiation techniques, including the chain rule and directional derivatives, to analyze functions of several variables.
2. To Utilize gradients, tangent planes, and optimization methods such as Lagrange multipliers to solve problems in constrained and unconstrained optimization.
3. To Evaluate double and triple integrals in Cartesian, polar, cylindrical, and spherical coordinate systems to compute areas, volumes, and other physical quantities.
4. To Apply Green's theorem, Stokes' theorem, and the Divergence theorem to solve problems involving vector fields and surface integrals.
5. To Develop problem-solving skills relevant to engineering, physics, and applied mathematics.

Course Outcomes:

By the end of this course, students will be able to:

CO1: Understand and analyze the concepts of multivariable functions, their continuity, differentiability, and optimization techniques.

- **ILO1.1**: Define and explain the limit, continuity, and differentiability of functions of multiple variables.
- **ILO1.2**: Apply the chain rule, directional derivatives, and gradient properties to solve problems in multivariable calculus.

CO2: Utilize optimization techniques and vector calculus concepts for constrained and unconstrained problems.

- **ILO2.1**: Solve extrema problems using first and second derivative tests, Lagrange multipliers, and constrained optimization techniques.
- **ILO2.2**: Define vector fields and compute divergence and curl in various applications.

CO3: Evaluate double and triple integrals in various coordinate systems and apply them to compute areas and volumes.

- **ILO3.1**: Compute double integrals over rectangular and non-rectangular regions using Cartesian and polar coordinates.
- **ILO3.2**: Apply triple integrals in Cartesian, cylindrical, and spherical coordinates to find volumes of solid regions.

CO4: Develop problem-solving skills in multi-integral calculus for real-world applications.

- **ILO4.1**: Determine the volume of solids using triple integrals over parallelepipeds and other regions.
- **ILO4.2**: Apply integral calculus techniques to physical and engineering problems.

CO5: Understand and apply the concept of change of variables in multiple integrals and evaluate line integrals.

- **ILO5.1**: Transform double and triple integrals using appropriate coordinate transformations.
- **ILO5.2**: Compute line integrals and apply them to determine mass and work in vector fields.

CO6: Analyze the properties of conservative vector fields and their applications.

- **ILO6.1**: Explain the fundamental theorem of line integrals and conditions for a vector field to be conservative.
- **ILO6.2**: Determine path independence in conservative fields and apply them in real-world scenarios.

CO7: Apply Green's theorem, Stokes' theorem, and the Divergence theorem to evaluate surface and flux integrals.

- **ILO7.1**: Use Green's theorem to convert line integrals into double integrals and solve related problems.
- **ILO7.2**: Compute surface integrals over parametrically defined surfaces.

CO8: Develop a conceptual and computational understanding of vector calculus theorems in physical applications.

- **ILO8.1**: Utilize Stokes' theorem to relate surface integrals to line integrals.
- **ILO8.2**: Apply the Divergence theorem to evaluate flux integrals in various vector fields.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL		**CO1**				
CONCEPTUAL		**CO2; CO5**	**CO1**			**CO4;CO8**
PROCEDURAL			**CO2;CO4 CO8**	**CO1;CO6**	**CO3**	
METACOGNITIVE			**CO3; CO5;CO7**			

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	Functions of several variables, limit and continuity of functions of two variables, Partial differentiation, total differentiability and differentiability, sufficient condition for	15	05	-	20

	differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl.				
II (16 Marks)	Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, cylindrical and spherical co-ordinates. Triple integrals, Triple integral over a parallelopiped and solid regions. Volume by triple integrals.	15	05	-	20
III (14 Marks)	Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.	09	03	-	12
IV (12 Marks)	Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.	06	02		08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz

TEXTBOOKS:

1. Thomas G. B. and Finney R. L., Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. Fitzpatrick P. M., Advanced Calculus, American Mathematical Society, 2005.

REFERENCE BOOKS:

1. Stewart J., Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.
2. Strauss M. J., Bradley G. L. and Smith K. J., Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. Marsden E., Tromba A. J. and Weinstein A., Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S
CO7	S	S	M	M	L	M	M	M	S	S
CO8	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Group theory-II**
Course Code	**:**	**MTHC10**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisites: Knowledge of Group Theory I(Second Semester)

Course Objectives: The course is intended to equip the learners with a strong foundation on group theory in aspects like Automorphism, Class equation, Group action, Direct Product of Groups and Sylow's theorems.

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: Construct new groups using the concept of automorphism.

ILO 1.1: Define and differentiate between inner and outer automorphisms of a group.
ILO 1.2: Construct automorphism groups for finite and infinite cyclic groups and analyze their structure.

CO2: Define Characteristic Subgroups, Commutator Subgroup.

ILO 2.1: Identify and prove the characteristic property of a given subgroup.
ILO 2.2: Compute the commutator subgroup of a given group and verify its key properties.

CO3: Solve problems related to the class equation.

ILO 3.1: Apply the concept of group actions to derive and interpret the class equation.
ILO 3.2: Solve problems involving the class equation to determine the number of conjugacy classes and their sizes.

CO4: Apply group action to study Cayley's theorem and class equation.

ILO 4.1: Use group action concepts to prove and illustrate Cayley's theorem.
ILO 4.2: Analyze how the class equation helps in the study of p-groups and their properties.

CO5: Establish properties of direct product.

ILO 5.1: Differentiate between internal and external direct products and establish their key properties.
ILO 5.2: Verify the Fundamental Theorem of Finite Abelian Groups using direct product decomposition.

CO6: Establish relation between direct and indirect product.

ILO 6.1: Compare and contrast direct and indirect products of groups with examples.
ILO 6.2: Analyze conditions under which a group can be expressed as an internal or external direct product.

CO7: Execute direct product to group of units modulo n.

ILO 7.1: Compute the group of units modulo n and express it as an external direct product.
ILO 7.2: Apply properties of external direct products to solve problems related to modular arithmetic.

CO8: Demonstrate Sylow's theorems and apply them to different problems.

ILO 8.1: State and prove Sylow's theorems and derive their consequences.
ILO 8.2: Apply Sylow's theorems to classify groups of small orders.

CO9: Apply non-simplicity tests.

ILO 9.1: Explain and apply non-simplicity tests for finite groups.
ILO 9.2: Verify the simplicity of alternating groups A_n for $n \geq 5$.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO2	CO8	X	X	X	X
CONCEPTUAL	X	CO1, CO5, CO6	CO3, CO9	X	X	X
PROCEDURAL	X	X	CO4, CO7	X	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.	15	05	-	20
II (15 Marks)	Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.	12	04	-	16
III (15 Marks)	Group action, Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups	12	04	-	16
IV (12 Marks)	Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for n ≥ 5, non-simplicity tests.	06	02		08

	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Analyze the Automorphisms for constructing new groups from the given group.
- Discuss the Group actions, Sylow theorems and their applications to check nonsimplicity.

TEXTBOOKS:

1. Bhattacharjee P. B., Jain S. K. & Nagpaul S. R., Basic Abstract Algebra, Cambridge University Press.
2. Gallian J. A., Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.

REFERENCE BOOKS:

1. Dummit D. S. and Foote R. M., Abstract Algebra, 3rd Ed., Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
2. Herstein I. N., Topics in Algebra, Wiley & Sons, 2006.
3. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
4. Artin M., Abstract Algebra, 2nd Ed., Pearson, 2011.
5. Durbin J. R., Modern Algebra, John Wiley & Sons, New York Inc., 2000.
6. Wallace D. A. R., Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	L	L	S	M	S	S	S
CO2	S	S	L	L	L	S	M	S	S	S
CO3	S	S	L	L	L	S	M	S	S	S
CO4	S	S	L	L	L	S	M	S	S	S
CO5	S	S	L	L	L	S	M	S	S	S
CO6	S	S	L	L	L	S	M	S	S	S
CO7	S	S	L	L	L	S	M	S	S	S
CO8	S	S	L	L	L	S	M	S	S	S
CO9	S	S	L	L	L	S	M	S	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Linear Programming**
Course Code	**:**	**MTHC11A**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description

This course provides an in-depth introduction to Linear Programming and its applications in optimization. Students will explore the fundamental concepts of the Simplex Method, duality theory, transportation and assignment problems, and game theory. Practical applications and real-life problem-solving techniques will be emphasized through case studies. The course balances theoretical understanding with hands-on computational techniques to equip students with skills in decision-making and resource optimization.

Prerequisites

- Basic knowledge of Linear Algebra.

Course Objectives:

1. To Formulate and solve Linear Programming Problems (LPP) using the Simplex Method.
2. To Understand and apply artificial variable techniques, including the Two-Phase and Big-M Methods.
3. To Interpret duality in linear programming and analyze primal-dual relationships.
4. To Solve transportation and assignment problems using various optimization methods.
5. To Apply game theory concepts to decision-making problems, including two-person zero-sum games.
6. To Utilize mathematical programming techniques to solve real-world optimization problems.

Course Outcomes:

By the end of this course, students will be able to:

CO1: Understand and analyze the fundamentals of linear programming and various solution methods.

ILO1.1: Define and explain the basic concepts of linear programming and formulate linear programming models.
ILO1.2: Apply the simplex method, including its tableau format, to find optimal solutions.
ILO1.3: Compare the two-phase method and Big-M method in handling artificial variables.
ILO1.4: Analyze real-life optimization problems and interpret results using case studies.

CO2: Analyze and apply duality principles to solve optimization problems.

ILO2.1: Formulate the dual problem corresponding to a given primal problem.
ILO2.2: Analyze the primal-dual relationships and interpret their economic significance.

ILO2.3: Utilize duality theory to verify the optimality of solutions.
ILO2.4: Apply duality concepts to solve real-world optimization problems.

CO3: Solve transportation and assignment problems using appropriate mathematical techniques.

ILO3.1: Formulate and solve transportation and assignment problems mathematically.
ILO3.2: Implement initial feasible solution techniques such as the northwest-corner method, least-cost method, and Vogel's approximation method.
ILO3.3: Develop an algorithmic approach for solving transportation and assignment problems.
ILO3.4: Apply transportation and assignment models to practical business and logistics problems.

CO4: Apply game theory concepts to solve competitive decision-making problems.

ILO4.1: Explain the fundamental concepts of two-person zero-sum games and their formulation.
ILO4.2: Apply different strategies, including mixed strategies, to solve game theory problems.
ILO4.3: Use graphical and linear programming methods to determine optimal game strategies.
ILO4.4: Solve real-world decision-making problems using game theory principles.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL		CO1				
CONCEPTUAL			CO1; CO2			CO3
PROCEDURAL			CO3	CO1; CO2		
METACOGNITIVE			CO4			

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two- phase method, Big- M method and their comparison. Practicum: One Case Study and Real-Life Problems.	15	05	-	20
II (12 Marks)	Duality, formulation of the dual problem, primal- dual relationships, economic interpretation of the dual.	06	02	-	08
III (15 Marks)	Transportation problem and its mathematical formulation, northwest- corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. Practicum: One Case Study and Real-Life Problems.	12	04	-	16
IV (15 Marks)	Game theory: formulation of two-person zero sum games, solving two-person zero sum games, games with mixed	12	04		16

	strategies, graphical solution procedure, linear programming solution of games. Practicum: One Case Study and Real-Life Problems.				
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Sharma J. K., Operations Research: Theory and Applications, 5th Edition, 2012.
2. Taha H. A., Operations Research, An Introduction, 8th Ed., Prentice- Hall India, 2006.

REFERENCE BOOKS:

1. Bazaraa M. S., Jarvis J. J. and Sherali H. D., Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. Hillier F. S. and Lieberman G. J., Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hadley G., Linear Programming, Narosa Publishing House, New Delhi, 2002.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	M	M	S	S
CO2	S	S	S	M	M	M	M	M	S	S
CO3	S	S	S	M	M	M	M	M	S	S
CO4	S	S	S	M	M	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Mathematical Methods**
Course Code	**:**	**MTHC11B**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Mathematical Methods is a unique course to initiate the students to some fundamental topics of Mathematics. This course equips students with scientific and mathematical techniques used to analyze complex systems and solve practical problems. Topics include Fourier Series, Laplace Transform and its applications. This course prepares students for advanced studies in various applications by developing skills, strategies and reasoning needed to succeed in mathematics.

Pre-Requisites:

- Introduction to Fourier Series and Laplace Transform.
- Basic concepts of calculus.
- Boundary Value Problems.

Course Objectives:

The course on Mathematical Methods-I aims the students to achieve in a more practical and definite ways. This sets the stage for more advanced mathematical concepts and real-world applications. It includes Fourier Series, Laplace Transform, its inverse and applications.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Discuss the importance of Fourier series in applied mathematics and analyze periodic functions.

ILO1.1: Learn the required conditions for deriving Fourier series representing common physical phenomena.

ILO1.2: Understand the convergence of Fourier series of continuous periodic functions.

ILO1.3: Understand the convergence of Fourier series at discontinuities.

CO2: Enable the students to study the Laplace Transform, properties of Laplace Transform, and some applications to solve the differential equations and integral equations.

ILO2.1: Learn the application of Laplace transform in engineering analysis.

ILO2.2: Learn the Laplace transform for ordinary derivatives and partial derivatives of different orders.

ILO2.3: Learn the required conditions for transforming variable or variables in functions by the Laplace transform.

CO3: Understanding for solving linear differential equations and analyzing system behavior in the frequency domain.

ILO3.1: Changes a function of a complex variable into a function of a real variable, usually time.

ILO3.2: Learn to use partial fractions and convolution methods in inverse Laplace transforms.

ILO3.3: Used in many fields, including engineering and physics, for solving differential equations, analyzing linear systems and optimization.

CO4: Describe a periodic signal in terms of cosine and sine waves.

ILO4.1: Used to analyze periodic functions into their fundamental and harmonic components.

ILO4.2: Model any periodic signal using a combination of sines and cosines.

ILO4.3: Represent both periodic real functions as well as solutions admitted by linear partial differential equations with assigned initial and boundary conditions.

CO5: Systematic approach for solving problems and finding solutions in various fields, from physics to engineering.

ILO5.1: Recognize Laplace and Fourier transform and use the appropriate method to solve them.

ILO5.2: Use an initial condition to find a solution of boundary value problem.

ILO5.3: Solve problems involving Laplace and Poisson equations.

Cognitive Map of Course Outcomes with Bloom’s Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create

Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		CO4
Procedural Knowledge			CO1, CO2	CO3	CO4	CO5
Metacognitive Knowledge					CO5	

UNITS	CONTENTS	L	T	P	Total Hours
I (9 Marks)	**Fourier Series:** Fourier Series, Dirichlet conditions, Fourier series for even and odd functions Half range Fourier series.	06	02	-	08
II (12 Marks)	**Laplace Transform:** Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals.	12	04	-	16
III (9 Marks)	**Inverse Laplace Transform:** Definition of Inverse Laplace Transform, Linearity property, first and second shifting theorems, change of scale, Convolution theorem.	03	01	-	04
IV (18 Marks)	**Fourier Transform, and Inverse Fourier transform:** Dirichlet conditions, Definition of Fourier transform, Inverse theorem for Fourier transform, Fourier Sine and Fourier cosine transforms and their inversion formula, Linearity property, change of scale property, shifting property, modulation theorem, convolution theorem.	15	05		20
V (12 Marks)	**Applications of Fourier and Laplace transform:** Solution of Boundary value problems and initial value problems in 1-D and 2-D cases. Solution of Laplace and Poisson equations in 2-D cases.	09	03		12
	Total	45	15	-	60

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - 20 Marks
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion

- Quiz
- Viva-Voce

TEXTBOOKS:

1. Sreennadh S., Ranganatham S., Prasad M V S S N, Babu V. R., Fourier series and Integral transform, S. Chand, New Delhi, 2008.
2. Spigel M. R., Theory and Problems of Laplace Transform, Schaum Outline Series, 2018.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	L	M	S	M	M	S
CO2	S	M	M	M	L	M	M	S	S	M
CO3	M	S	M	M	L	M	M	S	S	M
CO4	S	M	M	M	L	M	S	M	S	S
CO5	S	M	M	M	L	M	S	S	M	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Financial Mathematics**
Course Code	**:**	**MTHC11C**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an introduction to fundamental principles in financial mathematics and investment analysis. Topics include the time value of money, interest rate calculations, and risk aversion, as well as valuation methods for bonds and asset pricing models. Students will explore portfolio theory, diversification, and the Capital Asset Pricing Model (CAPM). Analytical techniques such as the Newton-Raphson method for internal rate of return (IRR) and optimization through Lagrange multipliers will also be covered. By the end of the course, students will develop a strong foundation in financial decision-making and investment strategies.

Prerequisites:

Students enrolling in this course should have a basic understanding of:

- Calculus
- Linear algebra

Course Objectives:

1. To Understand and apply the principles of arbitrage, risk aversion, and the time value of money.
2. To Calculate net present value (NPV) and internal rate of return (IRR) using numerical methods.
3. To Analyze bond pricing, yields, and duration, and assess strategies such as immunization and convexity adjustments.
4. To Compute portfolio returns and risks using statistical measures such as variance, covariance, and correlation.
5. To Apply the Markowitz model to construct optimal portfolios and understand the concept of diversification.
6. To Utilize the Capital Asset Pricing Model (CAPM) to evaluate stock and portfolio risk, and determine expected returns.
7. To Use performance measures such as the Sharpe and Jensen indices for investment evaluation.

.

Course Outcomes:

By the end of this course, the students will be able to:

CO1: Understand and apply the fundamental financial principles, including arbitrage, risk aversion, interest calculations, and project evaluation methods.

ILO1.1: Explain the concepts of arbitrage, risk aversion, and the time value of money.
ILO1.2: Apply simple and compound interest calculations in discrete and continuous cases.
ILO1.3: Compute net present value (NPV) and internal rate of return (IRR) using bisection and Newton-Raphson methods.

ILO1.4: Compare NPV and IRR for project evaluation and decision-making.

CO2: Analyze bond pricing, yields, duration, and term structure of interest rates for investment decisions.

ILO2.1: Calculate bond prices and yields using present value techniques.
ILO2.2: Evaluate Macaulay and modified duration and their impact on interest rate risk.
ILO2.3: Interpret the term structure of interest rates and compute spot and forward rates.
ILO2.4: Assess the effects of bond convexity, callable and putable features on pricing and investment strategies.

CO3: Understand and apply portfolio returns, risk assessment, and diversification using statistical tools and Markowitz model.

ILO3.1: Define asset return, short selling, and portfolio return concepts.
ILO3.2: Compute portfolio mean return and variance using expectation, variance, and covariance.
ILO3.3: Illustrate diversification benefits using the feasible set and portfolio diagrams.
ILO3.4: Apply Markowitz's optimization model to construct an efficient portfolio.

CO4: Apply capital market theories, asset pricing models, and performance indices in investment analysis.

ILO4.1: Explain the one-fund and two-fund theorems and their implications.
ILO4.2: Analyze the Capital Market Line (CML) and the Sharpe index for portfolio evaluation.
ILO4.3: Utilize the Capital Asset Pricing Model (CAPM) for stock and portfolio beta estimation.
ILO4.4: Evaluate investment performance using CAPM, security market line, and Jensen's index.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL						
CONCEPTUAL				**CO2; CO4**		
PROCEDURAL		**CO1; CO3**			**CO2; CO4**	
METACOGNITIVE			**CO1; CO2 CO3; CO4**			

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (12 Marks)	Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR.	06	02	-	08
II (18 Marks)	Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value,	15	05		20

	floating-rate bonds, immunization, convexity, putable and callable bonds.				
III (12 Marks)	Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).	09	03	-	12
IV (18 Marks)	One fund theorem, risk free assets, Two fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Learn the basic terms of financial markets and understand some computational and quantitative techniques required for working in the financial markets.

TEXTBOOKS:

1. Anthony M., Biggs N., Mathematics for Economics and Finance: Methods and Modelling, Cambridge University Press, Reprinted 2009.
2. Ross S. N., An Elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.

REFERENCE BOOKS:

1. Luenberger D. G., Investment Science, Oxford University Press, Delhi, 1998.
2. Hull J. C., Options, Futures and Other Derivatives, 6th Ed., Prentice-Hall India, Indian reprint, 2006.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Computer Programming**
Course Code	**:**	**MTHC11D**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=0, P=1)**
Distribution of Marks	**:**	**45 (End Sem) +15(Practical)+ 40 (In-Sem)**

Course Description:

This course introduces fundamental programming concepts using the C programming language. Students will learn essential problem-solving techniques, algorithm development, and program design using flowcharts and pseudocode. The course covers topics such as C tokens, variables, operators, expressions, control structures, arrays, functions, and recursion. Additionally, students will develop hands-on programming skills through practical assignments, reinforcing theoretical concepts with real-world applications.

Prerequisites:

1. Basic knowledge of computers and their operation.
2. Familiarity with mathematical concepts such as arithmetic operations and algebra.
3. Logical reasoning and problem-solving skills (no prior programming experience required).

Course Objectives:

1. To Understand the fundamental concepts of programming and problem-solving approaches.
2. To Develop algorithms and flowcharts for problem-solving.
3. To Write C programs using appropriate syntax and semantics.
4. To Utilize different operators, expressions, and mathematical functions effectively.
5. To Implement decision-making and looping constructs to control program execution.
6. To Handle input and output operations proficiently.
7. To Work with arrays, both single and multi-dimensional, for data storage and manipulation.
8. To Define and use user-defined functions, including recursion.
9. To Apply storage classes in C for efficient memory management.
10. To Develop practical programming skills through hands-on exercises and projects.

Course Outcomes:

By the end of this course, students will be able to:

CO1: Understand and apply the fundamental programming concepts, C tokens, operators, and input-output operations.

ILO1.1: Explain basic programming concepts, flowcharts, and algorithms.
ILO1.2: Identify and use different C tokens, keywords, identifiers, and data types.
ILO1.3: Apply arithmetic, logical, and relational operators in expressions.
ILO1.4: Demonstrate formatted input/output operations using scanf(), printf(), and character I/O functions.

CO2: Implement conditional statements and looping constructs to control program execution.

ILO2.1: Develop programs using if, if-else, and else-if ladder statements for decision-making.
ILO2.2: Use while, do-while, and for loops effectively for iterative operations.
ILO2.3: Implement branching mechanisms using break, continue, and goto statements.
ILO2.4: Apply exit() function to terminate programs when necessary.

CO3: Utilize arrays to store, process, and manipulate data.

ILO 3.1: Define and initialize one-dimensional and two-dimensional arrays.
ILO3.2: Perform operations such as matrix addition, subtraction, multiplication, and transpose.
ILO3.3: Implement array-based algorithms for searching and sorting.
ILO3.4: Develop programs using multi-dimensional arrays for structured data storage.

CO4: Implement user-defined functions and recursion for modular programming.

ILO4.1: Explain the elements of user-defined functions, function declaration, and function calls.
ILO4.2: Implement functions with arguments and return values for better modularity.
ILO4.3: Utilize recursion to solve problems like factorial and Fibonacci series.
ILO4.4: Demonstrate the use of storage classes (auto, static, register, extern) in C programs.

CO5: Develop real-world applications using C programming.

ILO5.1: Apply programming concepts to solve mathematical problems like interest calculation, series sum, and quadratic equations.
ILO5.2: Implement programs for number-based operations like prime checking, factorial computation, and palindrome detection.
ILO5.3: Develop programs for matrix manipulations, sorting algorithms, and salary computation.
ILO5.4: Demonstrate proficiency in writing efficient and optimized C programs.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL						
CONCEPTUAL		**CO1**				**CO2;CO3 CO5**
PROCEDURAL			**CO1;CO2; CO3;CO4**			
METACOGNITIVE			**CO5**			

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (15 Marks)	Basic programming concept, programming approach to solving problem, flowcharts, algorithm, character set, C tokens, keywords and identifiers, constants, variables, data types, declaration of variables, declaration storage class, assigning values to variables. Operators and expressions:	15	00	-	15

	Arithmetic operators, relational operators, logical operators, assignment operators, arithmetic expression, precedence of arithmetic operators, type conversion in expressions operator precedence and associativity, mathematical functions. Inut output operations, Reading and writing a character, formatted input and formatted output, Character input/ Output functions: getchar(), Putchar() etc.				
II (10 Marks)	Decision making and Branching, IF statement, IF...ELSE statement, nested IF, ELSE IF Ladder, WHILE statement, DO statement, FOR statement, Break, continue, go to statements, exit function	10	00	-	10
III (10 Marks)	Arrays, One dimensional arrays, declaration of one dimensional array, initialization of two dimensional arrays, multidimensional array.	10	00	-	10
IV (10 Marks)	User-defined functions, Elements of user defined functions, Definition of functions, return values and their types, function calls, function declaration, category of functions, no arguments and return values, arguments with return values, no arguments but returns a value, functions that return multiple values, Recursion, storage classes in C.	10	00	-	10
V (15 Marks)	**List of Practicals:** 1. Simple and compound interest 2. Sum of series, sum of first n natural numbers, sum of square of first n natural numbers, sum of cube of first n natural numbers. 3. Solution of quadratic equation 4. Checking the Prime numbers 5. Sum of sine, cosine and Fibonacci numbers 6. Mean and standard deviation 7. Printing of a matrix 8. Matrix addition, subtraction, multiplication, transpose 9. Sorting of numbers (ascending and descending) 10. Computation of salary 11. Finding the largest numbers among the three and n numbers. 12. Finding the factorial of a numbers using functions and recursion 13. Printing of even numbers and odd numbers in a range. 14. Sum of digits of integer. 15. Checking of palindrome of a numbers 16. Printing of numbers in various forms, number tables.	-	-	30	30
	Total	45	00	30	75

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Develop the understanding of an algorithm and its definition.
- Learn programming basics of C such as Data types, Mathematical and logical operations, if statement and loops etc.

TEXTBOOKS:

1. Jeyapoovan T., A First Course in Programming with C, Vikash Publishing House Pvt. Ltd.
2. Balagurusamy E., Programming in ANSI C; 4Ed, Tata McGrow-Hill Publishing Company Ltd, New Delhi.

REFERENCE BOOKS:

1. Kanetkar Y., Let us C, B.P. Publication.
2. Gottfried B. S., C- Programming, Tata McGrow Hill.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	M	S	S
CO2	S	S	S	M	S	M	M	M	S	S
CO3	S	S	S	M	S	M	M	M	S	S
CO4	S	S	S	M	S	M	M	M	S	S
CO5	S	S	S	M	S	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Computer Programming**
Course Code	**:**	**MINMTH5**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=0, P=1)**
Distribution of Marks	**:**	**45 (End Sem) +15(Practical)+ 40 (In-Sem)**

Course Description:

This course introduces fundamental programming concepts using the C programming language. Students will learn essential problem-solving techniques, algorithm development, and program design using flowcharts and pseudocode. The course covers topics such as C tokens, variables, operators, expressions, control structures, arrays, functions, and recursion. Additionally, students will develop hands-on programming skills through practical assignments, reinforcing theoretical concepts with real-world applications.

Prerequisites:

4. Basic knowledge of computers and their operation.
5. Familiarity with mathematical concepts such as arithmetic operations and algebra.
6. Logical reasoning and problem-solving skills (no prior programming experience required).

Course Objectives:

11. To Understand the fundamental concepts of programming and problem-solving approaches.
12. To Develop algorithms and flowcharts for problem-solving.
13. To Write C programs using appropriate syntax and semantics.
14. To Utilize different operators, expressions, and mathematical functions effectively.
15. To Implement decision-making and looping constructs to control program execution.
16. To Handle input and output operations proficiently.
17. To Work with arrays, both single and multi-dimensional, for data storage and manipulation.
18. To Define and use user-defined functions, including recursion.
19. To Apply storage classes in C for efficient memory management.
20. To Develop practical programming skills through hands-on exercises and projects.

Course Outcomes:

By the end of this course, students will be able to:

CO1: Understand and apply the fundamental programming concepts, C tokens, operators, and input-output operations.

ILO1.1: Explain basic programming concepts, flowcharts, and algorithms.
ILO1.2: Identify and use different C tokens, keywords, identifiers, and data types.
ILO1.3: Apply arithmetic, logical, and relational operators in expressions.
ILO1.4: Demonstrate formatted input/output operations using scanf(), printf(), and character I/O functions.

CO2: Implement conditional statements and looping constructs to control program execution.

ILO2.1: Develop programs using if, if-else, and else-if ladder statements for decision-making.
ILO2.2: Use while, do-while, and for loops effectively for iterative operations.
ILO2.3: Implement branching mechanisms using break, continue, and goto statements.
ILO2.4: Apply exit() function to terminate programs when necessary.

CO3: Utilize arrays to store, process, and manipulate data.

ILO 3.1: Define and initialize one-dimensional and two-dimensional arrays.
ILO3.2: Perform operations such as matrix addition, subtraction, multiplication, and transpose.
ILO3.3: Implement array-based algorithms for searching and sorting.
ILO3.4: Develop programs using multi-dimensional arrays for structured data storage.

CO4: Implement user-defined functions and recursion for modular programming.

ILO4.1: Explain the elements of user-defined functions, function declaration, and function calls.
ILO4.2: Implement functions with arguments and return values for better modularity.
ILO4.3: Utilize recursion to solve problems like factorial and Fibonacci series.
ILO4.4: Demonstrate the use of storage classes (auto, static, register, extern) in C programs.

CO5: Develop real-world applications using C programming.

ILO5.1: Apply programming concepts to solve mathematical problems like interest calculation, series sum, and quadratic equations.
ILO5.2: Implement programs for number-based operations like prime checking, factorial computation, and palindrome detection.
ILO5.3: Develop programs for matrix manipulations, sorting algorithms, and salary computation.
ILO5.4: Demonstrate proficiency in writing efficient and optimized C programs.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL						
CONCEPTUAL		**CO1**				**CO2;CO3 CO5**
PROCEDURAL			**CO1;CO2; CO3;CO4**			
METACOGNITIVE			**CO5**			

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (15 Marks)	Basic programming concept, programming approach to solving problem, flowcharts, algorithm, character set, C tokens, keywords and identifiers, constants, variables, data types, declaration of variables, declaration storage class, assigning values to variables. Operators and expressions:	15	00	-	15

	Arithmetic operators, relational operators, logical operators, assignment operators, arithmetic expression, precedence of arithmetic operators, type conversion in expressions operator precedence and associativity, mathematical functions. Inut output operations, Reading and writing a character, formatted input and formatted output, Character input/ Output functions: getchar(), Putchar() etc.				
II (10 Marks)	Decision making and Branching, IF statement, IF...ELSE statement, nested IF, ELSE IF Ladder, WHILE statement, DO statement, FOR statement, Break, continue, go to statements, exit function	10	00	-	10
III (10 Marks)	Arrays, One dimensional arrays, declaration of one dimensional array, initialization of two dimensional arrays, multidimensional array.	10	00	-	10
IV (10 Marks)	User-defined functions, Elements of user defined functions, Definition of functions, return values and their types, function calls, function declaration, category of functions, no arguments and return values, arguments with return values, no arguments but returns a value, functions that return multiple values, Recursion, storage classes in C.	10	00	-	10
V (15 Marks)	**List of Practicals:** 17. Simple and compound interest 18. Sum of series, sum of first n natural numbers, sum of square of first n natural numbers, sum of cube of first n natural numbers. 19. Solution of quadratic equation 20. Checking the Prime numbers 21. Sum of sine, cosine and Fibonacci numbers 22. Mean and standard deviation 23. Printing of a matrix 24. Matrix addition, subtraction, multiplication, transpose 25. Sorting of numbers (ascending and descending) 26. Computation of salary 27. Finding the largest numbers among the three and n numbers. 28. Finding the factorial of a numbers using functions and recursion 29. Printing of even numbers and odd numbers in a range. 30. Sum of digits of integer. 31. Checking of palindrome of a numbers 32. Printing of numbers in various forms, number tables.	-	-	30	30
	Total	45	00	30	75

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Develop the understanding of an algorithm and its definition.
- Learn programming basics of C such as Data types, Mathematical and logical operations, if statement and loops etc.

TEXTBOOKS:

3. Jeyapoovan T., A First Course in Programming with C, Vikash Publishing House Pvt. Ltd.
4. Balagurusamy E., Programming in ANSI C; 4Ed, Tata McGrow-Hill Publishing Company Ltd, New Delhi.

REFERENCE BOOKS:

3. Kanetkar Y., Let us C, B.P. Publication.
4. Gottfried B. S., C- Programming, Tata McGrow Hill.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	M	S	S
CO2	S	S	S	M	S	M	M	M	S	S
CO3	S	S	S	M	S	M	M	M	S	S
CO4	S	S	S	M	S	M	M	M	S	S
CO5	S	S	S	M	S	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**INTERNSHIP**
Course Code	**:**	**INTERNSHIP**
Nature of the Course	**:**	**INTERNSHIP**
Total Credits	**:**	**04**
Total Marks	**:**	**100**

OR

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Community Engagement**
Course Code	**:**	**Community Engagement**
Nature of the Course	**:**	**Community Engagement**
Total Credits	**:**	**04**
Total Marks	**:**	**100**

Community Engagement (NCC/NSS/Adult Education/ Student Mentoring/NGO/Govt. Institutions, etc.)

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Metric Spaces and Complex Analysis**
Course Code	**:**	**MTHC12**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an introduction to metric spaces and complex analysis, covering fundamental concepts such as open and closed sets, completeness, compactness, and continuity in metric spaces. The complex analysis portion explores analytic functions, Cauchy's theorem, contour integration, and residue calculus, with applications to real integrals and conformal mappings.

Prerequisite:

Real Analysis, Multivariable Calculus.

Course Objectives:

- To Understand and apply the concepts of metric spaces, including convergence, continuity, and compactness.
- To Develop a solid foundation in complex function theory.
- To Solve problems using Cauchy's integral theorem and residue calculus.
- To Apply conformal mappings to physical problems.

Course Outcome: On successful completion of the course, the students will be able to

CO1: Understand and Analyze the fundamental concepts of metric spaces and their properties.

- **ILO 1.1**: Define and explain metric spaces, open and closed sets, and their significance.
- **ILO 1.2**: Analyze the behavior of sequences in metric spaces, including Cauchy sequences and completeness.
- **ILO 1.3**: Apply Cantor's theorem and understand the concepts of dense and separable spaces.
- **ILO 1.4**: Demonstrate knowledge of subspaces, diameter, and closure properties in metric spaces.

CO2: Analyze the properties of continuous mappings, compactness, and connectedness.

- **ILO 2.1**: Explain different characterizations of continuity, including uniform continuity and homeomorphisms.

- **ILO 2.2**: Apply Banach's Fixed Point Theorem to solve mathematical problems.
- **ILO 2.3**: Differentiate between connected and disconnected sets and analyze connected subsets of $\mathbb{R}$.
- **ILO 2.4**: Evaluate compactness and its implications in metric spaces.

CO3: Develop an understanding of complex function theory, limits, and differentiability.

- **ILO 3.1**: Define and compute limits and continuity of functions in the complex plane.
- **ILO 3.2**: Analyze the properties of complex numbers and their geometric interpretations.
- **ILO 3.3**: Apply Cauchy-Riemann equations to determine differentiability.
- **ILO 3.4**: Develop mathematical proofs and applications of fundamental differentiation formulas.

CO4: Explore analytic functions, contour integration, and fundamental theorems in complex analysis.

- **ILO 4.1**: Identify and analyze examples of analytic functions, including exponential and trigonometric functions.
- **ILO 4.2**: Compute contour integrals and apply upper bound estimates.
- **ILO 4.3**: Apply Cauchy-Goursat theorem and Cauchy integral formula to solve problems.
- **ILO 4.4**: Evaluate definite integrals and use analytic techniques to study contour integration.

CO5: Understand and analyze advanced topics in complex analysis, including power series and convergence.

- **ILO 5.1**: Apply Liouville's theorem and the Fundamental Theorem of Algebra to complex functions.
- **ILO 5.2**: Analyze the convergence of sequences and series, including power series.
- **ILO 5.3**: Apply Taylor and Laurent series expansions.
- **ILO 5.4**: Differentiate between absolute and uniform convergence and apply them to problem-solving.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge		CO1				
Conceptual Knowledge		CO5	CO1	CO2; CO4		CO3
Procedural Knowledge			CO4	CO1; CO3 CO5	CO2; CO4	
Metacognitive Knowledge			CO2; CO3; CO5			

UNITS	CONTENTS	L	T	P	Total Hours
I (16 Marks)	Metric spaces: definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, Subspaces, diameter of a set, Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Cantor's theorem. dense sets, separable spaces.	15	05	-	20
II (11 Marks)	Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, compactness Banach Fixed point Theorem. Connectedness, connected subsets of R.	09	03	-	12
III (11 Marks)	Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.	09	03	-	12
IV (11 Marks)	Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula.	06	02	-	08
V (11 Marks)	Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.	06	02	-	08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Kumaresan S., Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
2. Simmons G. F., Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
3. Brown J. W. and Churchill R. V., Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.

REFERENCE BOOKS:

1. Shirali S. and Vasudeva H. L., Metric Spaces, Springer Verlag, London, 2006.
2. Bak J. and Newman D. J., Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Ring Theory & Linear Algebra II**
Course Code	**:**	**MTHC13**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course introduces the concept of polynomial rings, factorization, and divisibility in integral domains, along with key concepts in linear algebra such as dual spaces, eigenvalues, and the Cayley-Hamilton theorem. Students will also study inner product spaces, orthogonality, and spectral theory, gaining essential problem-solving skills in algebra and linear algebra.

Prerequisite:

- Linear Algebra
- Abstract Algebra
- Vector Space

Course Objective:

1. To Understand polynomial rings, factorization, and unique factorization domains.
2. To Analyze properties of integral domains, irreducibility, and Eisenstein's criterion.
3. To Develop expertise in dual spaces, eigenvalues, and invariant subspaces.
4. To Apply inner product space techniques, including Gram-Schmidt and least squares approximation.
5. To Explore spectral theory, orthogonal projections, and self-adjoint operators.

Course Outcome: After completion of the course students will be able to:

CO1: Understand the structure of polynomial rings over commutative rings and apply the division algorithm.
LO1.1: Define polynomial rings over commutative rings and explain their algebraic properties.
LO1.2: Apply the division algorithm to polynomials and analyze its consequences.
CO2: Explore factorization of polynomials, reducibility, and irreducibility tests.
LO2.1: Identify principal ideal domains and their role in polynomial factorization.
LO2.2: Use Eisenstein's criterion and other tests to determine the irreducibility of polynomials.
CO3: Analyze divisibility properties in integral domains and distinguish between irreducibles and primes.

LO3.1: Define and differentiate between irreducible and prime elements in an integral domain.
LO3.2: Explain divisibility rules and their applications in algebraic structures.
CO4: Understand the classification of factorization domains and their relationships.
LO4.1: Compare and contrast unique factorization domains (UFDs), principal ideal domains (PIDs), and Euclidean domains.
LO4.2: Provide examples of Euclidean domains and explain how they ensure unique factorization.
CO5: Develop an understanding of dual spaces, dual basis, and the transpose of linear transformations.
LO5.1: Define dual spaces and construct dual bases for given vector spaces.
LO5.2: Compute the transpose of a linear transformation and represent it in a dual basis.
CO6: Apply eigenvalue concepts, diagonalizability, and the Cayley-Hamilton theorem in linear algebra.
LO6.1: Determine eigenvalues, eigenvectors, and analyze conditions for diagonalizability.
LO6.2: Apply the Cayley-Hamilton theorem to compute minimal polynomials and analyze their significance.
CO7: Understand the properties of inner product spaces, orthogonality, and least squares approximation.
LO7.1: Apply the Gram-Schmidt orthogonalization process to construct orthonormal bases.
LO7.2: Solve least squares approximation problems and find minimal solutions for linear equations.
CO8: Analyze self-adjoint operators, orthogonal projections, and the Spectral theorem.
LO8.1: Differentiate between normal and self-adjoint operators and compute their spectral properties.
LO8.2: Apply the Spectral theorem to study eigenvalues and eigenvectors of symmetric matrices.
Mapping of Cos with Bloom's Taxonomy

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO1, CO7			CO3	CO5	
CONCEPTUAL		CO2	CO2, CO6	CO8		CO5
PROCEDURAL		CO3	CO1, CO2		CO6	
METACOGNITIVE		CO4	CO8			CO4

UNITS	CONTENTS	L	T	P	Total Hours
I (9 Marks)	Polynomial rings over commutative rings, division algorithm and consequences.	06	02	-	08
II (15 Marks)	Principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]**.** Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.	09	03	-	12
III (18 Marks)	Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.	15	05	-	20
IV (18 Marks)	Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Understand the fundamental concept of commutative rings, principal ideal domain, integral domains, unique factorization domains, and Euclidean domains.
- Learn the concept of dual spaces, eigen spaces and the minimal polynomial for a linear operator.
- Acquire the basic concepts of inner product spaces, self-adjoint operators and orthogonal projections.

TEXTBOOKS:

1. Gallian J. A., Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
2. Kumaresan S., Linear Algebra- A Geometric Approach, Prentice Hall ofIndia,1999.
3. Friedberg S. H., A. J. Insel A. J., L. E. Spence L. E., Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

REFERENCE BOOKS:

1. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. Strang G., Linear Algebra and its Applications, Thomson, 2007.
3. Hoffman K., Kunze R. A., Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4. Artin M., Abstract Algebra, 2nd Ed., Pearson, 2011.
5. Lang S., Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Wallace D. A. R., Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
7. Bhattacharjee P. B., Jain S. K. & Nagpaul S. R. Basic Abstract Algebra, Cambridge University Press, 1994.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S
CO7	S	S	M	M	L	M	M	M	S	S
CO8	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Number Theory**
Course Code	**:**	**MTHC14A**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Number Theory is a branch of mathematics that explores the properties and relationships of integers. This course covers fundamental topics such as divisibility, prime numbers, modular arithmetic, Diophantine equations, congruences, number-theoretic functions, and cryptographic applications. Students will develop problem-solving skills and logical reasoning through rigorous proofs and computational techniques.

Prerequisite:
Basic knowledge of algebra and mathematical proofs.

Course Objectives:

- To Understand and apply divisibility rules, prime factorization, and modular arithmetic.
- To Solve congruences and Diophantine equations.
- To Explore number-theoretic functions and their properties.
- To Analyze applications in cryptography.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: Understand and analyze the fundamental concepts of number theory and their applications in cryptography.

ILO1: Explain the fundamental concepts of number theory, including Euler's theorem, Fermat's Little theorem, and Wilson's theorem.
ILO2: Solve linear congruences and Diophantine equations using various number-theoretic techniques.
ILO3: Analyze the properties of prime numbers and conjectures like Goldbach's conjecture and the prime number theorem.
ILO4: Apply the Chinese Remainder Theorem to solve congruence equations.

CO2: Apply number theoretic functions and properties to solve mathematical problems.

ILO1: Define and compute number-theoretic functions such as Euler's phi-function and Möbius function.
ILO2: Apply the properties of Dirichlet products and totally multiplicative functions in solving problems.

ILO3: Analyze the behavior of the greatest integer function and its relation to divisor functions.
ILO4: Evaluate the properties of the Euler's phi-function and its applications in modular arithmetic.

CO3: Analyze integer properties, modular arithmetic, and congruences to solve cryptographic problems.

ILO1: Determine the order of integers modulo n and identify primitive roots for prime and composite numbers.
ILO2: Apply Euler's criterion and the Legendre symbol in solving quadratic congruences.
ILO3: Analyze the properties of quadratic reciprocity and their implications in number theory.
ILO4: Solve quadratic congruences for different moduli using advanced number theory techniques.

CO4: Evaluate cryptographic algorithms such as RSA encryption using number theory principles.

ILO1: Explain the fundamentals of public-key cryptography and RSA encryption

ILO2: Apply number-theoretic concepts to encrypt and decrypt messages using RSA.

ILO3: Analyze the security of RSA encryption based on number theory principles

ILO4: Evaluate the significance of Fermat's Last Theorem in modern mathematics.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL		**CO1**				
CONCEPTUAL			**CO1;CO2 CO3; CO4**			
PROCEDURAL				**CO1; CO3**	**CO2; CO4**	
METACOGNITIVE				**CO2; CO4**		

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (15 Marks)	A review on basic concepts of Number theory, Euler's theorem, Congruence Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.	09	03	-	12
II (18 Marks)	Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the	15	05	-	20

	greatest integer function, Euler's phi- function, reduced set of residues, some properties of Euler's phi-function.				
III (18 Marks)	Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.	15	05	-	20
IV (9 Marks)	Public key encryption, RSA encryption and decryption, solution of the equation $x^2 + y^2 = z^2$, Fermat's Last theorem (Statement only without proof).	06	02	-	08
	Total	45	15	-	45

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- Solve some of the open problems related to prime numbers, viz., Goldbach conjecture etc.
- Describe about number theoretic functions and modular arithmetic.
- Learn about Public crypto systems, in particular, RSA

TEXTBOOKS:

1. Burton D. M., Elementary Number Theory, 6th Ed., Tata McGraw- Hill, Indian reprint, 2007.
2. Niven I., Zuckerman H. S., Montgomery H. L., An Introduction to the Theory of Numbers, 5th Ed., Wiley, 2008.

REFERENCE BOOK:

1. Robbins N., Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2005.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Mechanics**
Course Code	**:**	**MTHC14B**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an in-depth understanding of the fundamental principles of statics and dynamics, including force systems, equilibrium, friction, and moments of inertia. It covers topics such as force and moment equilibrium, free-body diagrams, Coulomb friction laws, centroid and moment of inertia, work-energy principles, and motion of rigid bodies. Applications include structures, belt transmission, screw jacks, and rotational motion. The course also introduces concepts of conservation of energy and momentum for particles and rigid bodies.

Prerequisite:

Fundamentals of Physics, Calculus, and Linear Algebra.

Course Objectives:

1. To Analyze force systems and compute moments about a point, an axis, and a line.
2. To Determine the equilibrium of rigid bodies using free-body diagrams and general equations of equilibrium.
3. To Solve static indeterminacy problems involving structures and distributed force systems.
4. To Apply Coulomb friction laws to practical applications such as belt drives, wedges, and screw jacks.
5. To Compute centroids, moments of area, and apply the Theorem of Pappus-Guldinus.
6. To Utilize work-energy principles for analyzing mechanical systems involving kinetic energy and momentum.
7. To Describe the motion of particles and rigid bodies using velocity and acceleration relationships in different reference frames.
8. To Apply Chasles' theorem and analyze rotational and translational motion in dynamic systems.

Course Outcomes: On successful completion of the course, the students will be able to

CO1: Understand and analyze force systems and equilibrium conditions for static structures.

- **ILO 1.1**: Define and explain the concept of moment, couple, and force systems.
- **ILO 1.2**: Construct and analyze free-body diagrams, including internal forces.

- **ILO 1.3**: Apply equilibrium equations to solve problems related to force systems.
- **ILO 1.4**: Evaluate the static determinacy of structural components.

CO2: Analyze frictional forces and determine geometric properties of areas in engineering applications.

- **ILO 2.1**: Explain the laws of Coulomb friction and solve friction-based problems.
- **ILO 2.2**: Analyze power transmission in belt drives, screw jacks, and wedges.
- **ILO 2.3**: Compute centroid, first moments, and second moments of area.
- **ILO 2.4**: Apply Pappus-Guldinus theorem and determine principal axes of inertia.

CO3: Apply work-energy principles to analyze mechanical systems and particle dynamics.

- **ILO 3.1**: Define conservative force fields and analyze energy conservation principles.
- **ILO 3.2**: Formulate and apply the work-energy equation in dynamic systems.
- **ILO 3.3**: Evaluate kinetic energy and work expressions based on the center of mass.
- **ILO 3.4**: Solve real-world problems using the work-energy theorem.

CO4: Develop an understanding of motion analysis, rigid body dynamics, and reference frame transformations.

- **ILO 4.1**: Derive and apply the moment of momentum equation for particles and rigid bodies.
- **ILO 4.2**: Analyze translation and rotation of rigid bodies using Chasles' theorem.
- **ILO 4.3**: Establish and interpret time derivatives of vectors in different reference frames.
- **ILO 4.4**: Determine velocity and acceleration of particles using multiple reference frames.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**
FACTUAL		**CO1**				
CONCEPTUAL					**CO1; CO3**	**CO5**
PROCEDURAL				**CO1; CO2 CO3; CO5**		
METACOGNITIVE			**CO1; CO2; CO3; CO5**			

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two-point equivalent loading, problems arising from structures, static indeterminacy.	09	03	-	12
II (18 Marks)	Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems, relation between second moments and products of area, polar moment of area, principal axes.	15	05	-	20
III (9 Marks)	Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass	06	02	-	08
IV (18 Marks)	Moment of momentum equation for a single particle and a system of particles, translation and rotation of rigid bodies, Chasles' theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

- Shames I. H. and Rao G. K. M., Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
- Hibbeler R. C. and Gupta A., Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Hydro-Mechanics**
Course Code	**:**	**MTHC14C**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an in-depth study of fluid dynamics, covering both theoretical and practical aspects of fluid motion. Students will explore fundamental concepts such as kinematics of fluids, equations of motion, and pressure distribution in static and dynamic fluids. The course also delves into advanced topics like irrotational motion, circulation, and stability of floating bodies. Through theoretical analysis and real-world examples, students will develop a solid understanding of fluid behavior, essential for applications in engineering and physical sciences.

Prerequisites:

To enroll in this course, students should have prior knowledge of:

- Basic calculus (differentiation and integration).
- Vector analysis
- Basic Physics

Course Objectives:

1. To Apply the Eulerian and Lagrangian methods to analyze fluid motion.
2. To Derive and utilize key fluid motion equations such as Euler's equation, Bernoulli's equation, and the equation of continuity.
3. To Analyze irrotational motion and apply Green's theorem, uniqueness theorems, and Kelvin's minimum energy theorem.
4. To Comprehend fluid pressure principles, equilibrium conditions, and related mathematical formulations.
5. To Calculate the resultant pressure and center of pressure for various geometrical shapes under different conditions.
6. To Evaluate the stability of floating bodies and determine the metacentric height for stability analysis.
7. To Apply theoretical concepts to solve real-world fluid dynamics problems in engineering and physical sciences.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: Analyze the fundamental concepts of fluid motion and kinematics.

ILO1.1: Differentiate between real and ideal fluid and describe various flow patterns.

ILO1.2: Apply Eulerian and Lagrangian approaches to fluid motion analysis.

ILO1.3: Derive and interpret the equation of continuity for fluid flow.

ILO1.4: Analyze the acceleration of a fluid particle using kinematic principles.

CO2: Apply governing equations of motion to solve fluid dynamics problems.

ILO2.1 Derive and apply Euler's equation of motion for fluid flow.

ILO2.2: Explain Bernoulli's equation and its applications in steady motion.

ILO2.3: Describe the concept of circulation and Kelvin's circulation theorem.

ILO2.4: Solve problems related to impulsive motion in fluid dynamics.

CO3: Evaluate irrotational fluid motion using potential flow theory and related theorems.

ILO3.1: Explain the concept of potential flow and its applications.

ILO3.2: Apply Green's theorem to derive fluid motion properties.

ILO3.3: Evaluate kinetic energy distribution in a fluid system.

ILO3.4: Utilize uniqueness and Kelvin's minimum energy theorem in flow analysis.

CO4: Examine fluid pressure distribution and its impact on equilibrium conditions.

ILO4.1: Define and apply fundamental theorems of fluid pressure.

ILO4.2: Explain the relationship between pressure variation and equilibrium conditions.

ILO4.3: Solve problems related to equi-pressure surfaces and lines of force.

ILO4.4: Analyze the pressure distribution in static fluids using differential equations.

CO5: Determine resultant pressure and center of pressure for various surfaces.

ILO5.1: Calculate the resultant pressure on submerged surfaces.

ILO5.2: Determine the center of pressure for various geometrical shapes.

ILO5.3: Analyze the effect of fluid thrust on curved surfaces.

ILO5.4: Solve practical problems involving hydrostatic pressure distribution.

CO6: Assess equilibrium and stability of floating bodies through metacentric analysis.

ILO6.1: Explain the conditions of equilibrium for floating bodies.

ILO6.2: Differentiate between stable, unstable, and neutral equilibrium.

ILO6.3: Determine the metacentric height and its role in stability analysis.

ILO6.4: Solve real-world problems related to floating bodies and ship stability.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL						
CONCEPTUAL		CO2				
PROCEDURAL			CO2	CO1; CO4 CO5	CO3; CO6	
METACOGNITIVE			CO1; CO3 CO4; CO5 CO6			

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	**Kinematics:** Real and ideal fluid, velocity of a fluid at a point, Eulerian and Lagrangian method, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, local and particle rate of change, equation of continuity, examples, acceleration of a fluid at a point, General analysis of fluid motion.	09	03	-	12
II (9 Marks)	**Equation of Motion:** Euler's equation of motion, Bernoullis equation, steady motion under conservative forces, impulsive motion, circulation, Kelvin's circulation theorem.	06	02	-	08
III (9 Marks)	**General theory of irrotational motion:** Potential flow, deductions from Green's theorem, kinetic energy of a liquid, uniqueness theorems, Kelvin's minimum energy theorem, Mean value of velocity potential.	06	02	-	08
IV (9 Marks)	**Fluid Pressure:** Introduction, Fluid Pressure and related theorems, Density and specific gravity, Theorems on fluid pressure under gravity, Rate of variation of pressure, Differential equation of pressure, Condition of equilibrium, Equi-pressure surfaces and lines of force, Curves of equi-pressure and equi-density, Examples.	09	03	-	12
V (12 Marks)	**Resultant Pressure and Centre of Pressure:** Resultant fluid pressure and related theorems, Centre of pressure, Determination of centre of pressure of parallelogram, triangle, circle under different conditions, Examples, Thrust on curved surfaces, Examples.	09	03	-	12
VI (9 Marks)	**Equilibrium and Stability of Floating Bodies:** Condition of equilibrium of floating bodies, Examples, Unstable and Neutral equilibrium, Determination of Meta centre, Examples.	06	02	-	08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Chorlton F., Text Books of Fluid Dynamics; CBS Publishers & Distributors, 2005.

2. Raisinghania M. D., Fluid Dynamics; S. Chand & Company Ltd, 1995.

3. Ray M. and Sharma H. S., A Text Book of Hydrostatics; S. Chand & Company Ltd, New Delhi, 1989.

REFERENCE BOOK:

1. Thomson L. M., Theoretical Hydrodynamics, Dover Publications Inc., 1996.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Discrete Mathematics**
Course Code	**:**	**MTHC15A**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides a foundational understanding of ordered sets, lattices, Boolean algebra, and graph theory. Students will explore the structure and properties of lattices, including modular and distributive lattices, Boolean algebras, and their applications in logic and circuit design. The course also introduces fundamental concepts in graph theory, covering graph structures, isomorphisms, trees, circuits, and algorithms for shortest paths and optimization problems. Special emphasis is placed on applications such as switching circuits and algorithmic solutions to graph-related problems.

Prerequisites:

- Set theory and elementary algebra
- Logical reasoning and basic proof techniques

Course Objectives:

1. To Understand the fundamental concepts and properties of ordered sets and lattices.
2. To Apply the duality principle and analyze various types of lattices, including modular, distributive, and Boolean lattices.
3. To Utilize Boolean polynomials and simplification techniques such as the Quinn-McCluskey method and Karnaugh diagrams in circuit design.
4. To Recognize and analyze different types of graphs, including pseudographs, bipartite graphs, and complete graphs.
5. To Identify key properties of trees, paths, and circuits, and apply algorithms such as Dijkstra's and Floyd-Warshall's for solving shortest path problems.
6. To Solve real-world problems related to switching circuits, optimization, and network connectivity using lattice and graph theory principles.

Course Outcome: On successful completion of the course, the students will be able to

CO1: Understand and apply fundamental concepts of ordered sets, lattices, and their algebraic structures.

- **ILO 1.1** Explain the definitions, properties, and examples of ordered sets, lattices, and algebraic structures with appropriate mathematical reasoning.

- **ILO 1.2** Apply the concepts of ordered sets and lattice theory to solve problems related to sublattices, homomorphisms, and product lattices in real-world and computational contexts.

CO2: Apply modular and distributive lattices, Boolean algebra, and Boolean polynomials in problem-solving.

- **ILO 2.1 :** Utilize the properties of modular and distributive lattices to simplify algebraic expressions and solve mathematical problems related to lattice structures.
- **ILO 2.2 :** Analyze and manipulate Boolean polynomials using algebraic methods to optimize logical expressions and simplify digital circuit designs.

CO3: Solve problems using Quinn-McCluskey method, Karnaugh diagrams, and analyze switching circuits.

- **ILO 3.1 :** Apply the Quinn-McCluskey method and Karnaugh diagrams to simplify Boolean functions and optimize logical expressions.
- **ILO 3.2 :** Analyze and design switching circuits by implementing Boolean function simplifications to improve efficiency in digital logic design.

CO4: Understand and analyze different types of graphs and their properties, including bipartite and complete graphs.

- **ILO 4.1 :** Describe the fundamental properties of graphs, including bipartite, complete, and pseudographs, with relevant examples.
- **ILO 4.2 :** Classify and analyze different types of graphs based on their structural properties and apply graph theory concepts to solve real-world problems.

CO5: Apply advanced graph theory concepts like isomorphism, Eulerian and Hamiltonian graphs, and adjacency matrices.

- **ILO 5.1 :** Apply graph isomorphism techniques and properties of Eulerian and Hamiltonian graphs to determine connectivity and traversal paths in complex snetworks.
- **ILO 5.2 :** Use adjacency matrices to analyze graph structures, compute graph properties, and solve problems related to network optimization and shortest path algorithms.

CO6: Implement shortest path algorithms such as Dijkstra's and Floyd-Warshall in real-world optimization problems.

- **ILO 6.1 :** Implement Dijkstra's and Floyd-Warshall algorithms to compute the shortest paths in weighted graphs and optimize route planning in real-world scenarios.
- **ILO 6.2 :** Analyze the efficiency and computational complexity of shortest path algorithms and apply them to solve real-world optimization problems such as network routing and transportation planning.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE		CO1; CO4				
CONCEPTUAL KNOWLEDGE			CO2 CO3			
PROCEDURAL KNOWLEDGE			CO1 CO5	CO2; CO3 CO4; CO6		
METACOGNITIVE KNOWLEDGE						

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms.	12	04	-	16
II (18 Marks)	Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn- McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.	12	04	-	16
III (9 Marks)	Definitions, examples and basic properties of graph, pseudographs, complete graphs, bipartite graphs.	06	02	-	08
IV (18 Marks)	Isomorphism of graphs, Tree, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics

- Assignment
- Group Discussion
- Quiz
- Viva-Voce

TEXTBOOKS:

1. Davey B. A. and Priestley H. A., Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2. Goodaire E. G. and Parmenter M. M., Discrete Mathematics with Graph Theory (2nd Edition), Pearson Education (Singapore), Pte. Ltd., Indian Reprint, 2003.

REFERENCE BOOK:

1. Lidl R. and Pilz G., Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint, 2004.

Mapping of Course Outcomes to Program Outcomes:

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CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S
CO6	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Probability and Statistics**
Course Code	**:**	**MTHC15B**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an elementary introduction to probability and statistics with applications. Probability is the study of chance and is a very fundamental subject that we apply in everyday living, while statistics is more concerned with how we handle data using different analysis techniques and collection methods. Topics include mathematical expectation, moment generating function, Joint cumulative distribution function, Central Limit theorem, covariance, linear regression, Chebyshev's inequality.

Pre-Requisites:

- Understanding of probability theory.
- Basic concepts of calculus.
- Random experiment, Outcomes, Sample space, and Event.

Course Objectives:

The main objectives of this course is to provide students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science. This sets the stage for more advanced mathematical concepts and real-world applications. Its goals are to identify distributions, analyze data, and understand probability concepts.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Define the principal concepts about probability.

ILO1.1: Achieve a solid understanding of concept of random event.

ILO1.2: Express the features of discrete and continuous random variables.

ILO1.3: Formulate the distribution functions.

CO2: Understanding the fundamental concepts of a joint pmf, pdf and cdf of two random variables.

ILO2.1: Finding the frequency of occurrence of values for the given phenomena using cumulative frequency analysis.

ILO2.2: Able to compute probabilities and marginal from a joint pmf or pdf.

ILO2.3: Able to test whether two random variables are independent.

CO3: Understanding the difference between covariance and correlation.

ILO3.1: Used to determine if two variables are dependent on each other.

ILO3.2: Learn about the differences and similarities between covariance and correlation, and explore their applications.

ILO3.3: Analyze and widely used in various fields, including finance, economics, and science.

CO4: Investigate and illustrate the central limit theorem.

ILO4.1: Describe sampling distributions of the sample mean using the theorem.

ILO4.2: Calculate the standard deviation of sampling distributions using the theorem.

ILO4.3: Provides a solid foundation for performing hypothesis tests, making statistical estimates more reliable and accurate.

CO5: Joint cumulative distribution function helps to understand how to characterize the probability distribution of a random vector.

ILO5.1: Recognize the probability that two conditions are true simultaneously.

ILO5.2: Essential for various applications in statistics, such as hypothesis testing, confidence interval estimation, and data analysis.

ILO5.3: Fundamental concept in the field of statistics and probability theory.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO4		CO5
Procedural Knowledge			CO1, CO2	CO3	CO4	CO5
Metacognitive Knowledge					CO5	CO4

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.	15	05	-	20
II (18 Marks)	Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient.	15	05	-	20
III (9 Marks)	Joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables (Matrix approach), Chebyshev's inequality.	03	01	-	04

IV (15 Marks)	Statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance.	12	04	-	16
	Total	45	15	-	60

where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Ross S., First Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
2. Mood A. M., Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.

REFERENCE BOOKS:

1. Hogg R. V., McKean J. W. and Craig A. T., Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Miller I. and Miller M., Freund J. E., Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	S	M	M	S
CO2	S	S	M	M	L	M	M	S	S	M
CO3	S	S	M	M	L	M	M	S	S	M
CO4	S	S	M	M	L	M	S	M	S	S
CO5	S	S	M	M	L	M	S	S	M	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Numerical Methods**
Course Code	**:**	**MINMTH6**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course introduces numerical methods for solving mathematical problems that cannot be solved analytically. It covers root-finding techniques, interpolation, numerical differentiation and integration, solutions of linear and nonlinear equations, and numerical solutions of ordinary and partial differential equations. Emphasis is placed on error analysis, stability, and efficiency of algorithms.

Prerequisites:

Basic knowledge of calculus, linear algebra, and differential equations.

Course Objectives:

1. To understand the fundamental concepts of numerical methods and their applications.
2. To develop computational skills for solving mathematical problems numerically.
3. To analyze errors and convergence in numerical computations.

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: Understand and apply numerical techniques for finding roots of nonlinear equations.

ILO1.1: Explain the concepts of convergence and error analysis in numerical root-finding methods.

ILO1.2: Implement and compare different root-finding methods, including Bisection, False Position, and Newton's method.

ILO1.3: Analyze the efficiency and limitations of iterative techniques such as Secant and Fixed-Point iteration.

CO2: Solve linear systems using direct and iterative numerical methods.

ILO2.1: Apply LU decomposition for solving linear equations efficiently.

ILO2.2: Implement iterative techniques like Gauss-Jacobi, Gauss-Seidel, and Successive Over-Relaxation (SOR).

ILO2.3: Compare the convergence properties and stability of different iterative methods.

CO3: Apply interpolation techniques and numerical differentiation methods.
ILO3.1: Use Lagrange and Newton interpolation for polynomial approximation of functions.
ILO3.2: Implement finite difference operators for function estimation and numerical differentiation.
ILO3.3: Analyze the accuracy of forward, backward, and central difference methods for numerical differentiation.

CO4: Understand and apply numerical integration techniques and Euler's method for differential equations.
ILO4.1: Implement numerical integration techniques like Trapezoidal and Simpson's rules.
ILO4.2: Apply Euler's method for solving ordinary differential equations.
ILO4.3: Evaluate the accuracy and error behavior of numerical integration and Euler's method.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge		CO1; CO4				
Conceptual Knowledge			CO4	CO1; CO3		
Procedural Knowledge			CO1; CO2; CO3		CO4	
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method	12	04	-	16
II (15 Marks)	LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.	12	04	-	16
III (15 Marks)	Linear and higher order Lagrange and Newton interpolation: finite difference operators. Numerical differentiation: forward difference, backward difference and central Difference.	12	04	-	16
IV (15 Marks)	Integration: trapezoidal rule, Simpson's rule, Euler's method.	09	03	-	12
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

LEARNING OUTCOMES:

After the completion of this course, the learner will be able to:

- find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
- Use Interpolation techniques to compute the values for a tabulated function at points not in the table.
- Apply numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

TEXTBOOKS:

1. Bradie B., A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. Jain M. K., Iyengar S. R. K. and Jain R. K., Numerical Methods for Scientific and Engineering, Computation, 6th Ed., New age International Publisher, India, 2007.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	M	S	S
CO2	S	S	M	M	M	M	M	M	S	S
CO3	S	S	M	M	M	M	M	M	S	S
CO4	S	S	M	M	M	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Field Theory**
Course Code	**:**	**MTHC16**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisites: Knowledge of group structure and Ring structure.

Course Objectives: The course is intended to introduce the learners to the fundamentals of Field Extension, Galois Thery and Finite Fields**.**

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: Prove the fundamental theorem of Field theory

ILO 1.1: Explain the fundamental theorem of field theory and its implications.
ILO 1.2: Apply the fundamental theorem to analyze different types of field extensions.

CO2: Obtain the splitting field of a given polynomial

ILO 2.1: Construct the splitting field of a polynomial over a given field.
ILO 2.2: Determine the degree of the splitting field over the base field.

CO3: Deduce criteria for the existence of multiple roots of a polynomial

ILO 3.1: Identify conditions under which a polynomial has multiple roots.
ILO 3.2: Use derivative criteria to determine the presence of repeated roots.

CO4: Define type and degree of extensions

ILO 4.1: Differentiate between algebraic and transcendental extensions.
ILO 4.2: Calculate the degree of a given field extension.

CO5: Establish characterization of extensions

ILO 5.1: Classify field extensions based on their algebraic properties.
ILO 5.2: Establish conditions under which extensions are normal, separable, or simple.

CO6: Establish the relation between Field Theory and Group Theory using Galois Theory

ILO 6.1: Describe the Galois group of a polynomial and its role in field extensions.
ILO 6.2: Analyze the correspondence between subfields and subgroups of the Galois group.

CO7: Classify finite fields

ILO 7.1: Prove the existence and uniqueness of finite fields of a given order.
ILO 7.2: Construct explicit examples of finite fields and their elements.

CO8: Characterize the structure of finite fields

ILO 8.1: Describe the multiplicative group structure of a finite field.
ILO 8.2: Determine the number of elements and subfields of a given finite field.

CO9: Obtain necessary and sufficient conditions for finite subfields

ILO 9.1: Derive the conditions under which a subfield of a finite field exists.
ILO 9.2: Establish the relation between the order of a finite field and its subfields.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	X	CO4	CO1, CO9	X	X	X
CONCEPTUAL	X	CO3, CO7	CO2	X	X	X
PROCEDURAL	X	CO5, CO8	X	CO6	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (16 Marks)	Field Extensions, Fundamental Theorem of Field Theory, Splitting Fields.	12	04	-	16
II (16 Marks	Zeroes of an Irreducible Polynomial, Perfect Field. Algebraic Extensions, Properties of Algebraic Extensions.	12	04	-	16
III (10 Marks)	Introduction to Galois theory, Fundamental Theorem of Galois Theory(Proof not required)	06	02	-	08
IV (18 Marks)	Finite Fields, Classification of Finite Fields, Structure of Finite Fields, Subfields of a Finite Field.	15	05	-	20
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Gallian, J. A.(2013). Contemporary Abstract Algebra, New Age International(Chapter 20, 21, 22 and 32).

2. Dummit, D. S., Foote, R. M. (2004). Abstract Algebra. Hoboken: Wiley.

REFERENCE BOOKS:

1. Hungerford, T. W., Algebra. (1974). Springer-Verlag. New York.

2. Bhattacharya, P. B., Jain, S. K., Nagpaul, S. R. (1994). Basic Abstract Algebra. Cambridge University Press.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	S	M	S	S	S
CO2	S	S	M	M	L	S	M	S	S	S
CO3	S	S	M	M	L	S	M	S	S	S
CO4	S	S	M	M	L	S	M	S	S	S
CO5	S	S	M	M	L	S	M	S	S	S
CO6	S	S	M	M	L	S	M	S	S	S
CO7	S	S	M	M	L	S	M	S	S	S
CO8	S	S	M	M	L	S	M	S	S	S
CO9	S	S	M	M	L	S	M	S	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Tensor Analysis**
Course Code	**:**	**MTHC17**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course introduces the fundamental concepts of tensor analysis, emphasizing its applications in differential geometry and physics. Topics include tensor algebra, covariant and contravariant components, transformations, Christoffel symbols, and curvature tensors. Students will explore tensor calculus in various coordinate systems, with applications to mechanics, relativity, and continuum mechanics.

Pre-requisites:

Basics of vector algebra and vector analysis

Course Objectives:

1. To Develop proficiency in tensor transformations and operations.
2. To Apply tensor calculus to differential geometry and physics.
3. To Analyze Christoffel symbols and curvature tensors.
4. To Solve real-world problems using tensor methods.
5. To Explore applications of tensors in relativity and mechanics.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: Understand and apply the fundamental concepts of Cartesian tensors in mathematical and physical contexts.

- **ILO 1.1:** Explain scalars, vectors, tensors, and their transformation laws.
- **ILO 1.2:** Perform algebraic operations using Kronecker delta, permutation symbols, and Cartesian summation conventions.
- **ILO 1.3:** Compute gradient, divergence, curl, and Laplacian using index notation.
- **ILO 1.4:** Apply Gauss, Stokes, and Green's theorems in tensor notation.

CO2: Analyze and derive transformations in rectilinear and curvilinear coordinate systems.

- **ILO 2.1:** Define and determine reciprocal basis vectors in rectilinear coordinates.
- **ILO 2.2:** Explain proper transformations and derive reciprocal basis vectors in curvilinear coordinates.

CO3: Develop mathematical proficiency in tensor operations and their applications in curvilinear coordinate systems.

- **ILO 3.1:** Define general tensors, metric tensors, and permutation tensors.
- **ILO 3.2:** Perform tensor algebra in curvilinear coordinate systems using the quotient rule.
- **ILO 3.3:** Compute scalar product, vector product, and scalar triple product in different forms.

CO4: Apply Christoffel symbols and covariant differentiation to solve mathematical and physical problems.

- **ILO 4.1:** Derive Christoffel symbols in terms of the metric tensor and analyze their transformations.
- **ILO 4.2:** Compute covariant derivatives of vectors and second-order tensors.
- **ILO 4.3:** Apply Ricci's theorem and intrinsic derivative in different coordinate systems.
- **ILO 4.4:** Use tensor calculus in fluid dynamics applications, including gradient, divergence, curl, and Laplacian computations in curvilinear coordinates.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE						CO3
CONCEPTUAL KNOWLEDGE		CO1; CO2	CO3			
PROCEDURAL KNOWLEDGE			CO1; CO3; CO4	CO2		
METACOGNITIVE KNOWLEDGE						

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	**Cartesian Tensor:** Scalars, Vectors and Tensors; Index notation and Cartesian summation convention, Kronecker delta and permutation Symbols, Cartesian coordinate and rotation of axes, laws of transformation of base vectors, algebra of Cartesian tensors, principal axes and second order tensors, partial derivatives of scalar and vector field; gradient, divergence, curl and Laplacian; Gauss, Stokes and Green's theorems in index notation.	12	04	-	16
II (9 Marks)	**Rectilinear and Curvilinear coordinate systems:** Rectilinear coordinate systems, reciprocal basis, derivation of formula for determining reciprocal basis, curvilinear coordinate systems, proper transformations, basis and reciprocal basis in curvilinear coordinate system.	09	03	-	12
III (15 Marks)	**General tensor and the metric tensor:** General tensors, the metric tensor, the permutation tensors, tensor algebra in curvilinear coordinate system, the quotient rule, physical components of a vector in curvilinear coordinate system; scalar product, vector product and scalar triple product in various forms.	12	04	-	16
IV (18 Marks)	**Christoffel symbols and Covariant differentiation** Partial derivative of a vector, Christoffel symbols in terms of derivative of metric tensor, Christoffel symbols in orthogonal curvilinear systems, transformation of Christoffel symbols, covariant derivative of vectors and second order tensors, laws of covariant derivatives, Ricci's theorem, gradient, divergence, curl and Laplacian in curvilinear coordinate systems, intrinsic derivative, application of tensors in fluid dynamics.	12	04	-	16

	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Young, E. C. (2017). Vector and tensor analysis. CRC Press.
2. Aris, R. (2012). Vectors, tensors and the basic equations of fluid mechanics. Courier Corporation.

REFERENCE BOOKS:

1. Sharma, B. R. (2017). Tensor Analysis: A Primer. Mahaveer publications
2. Jeffreys, B. (1969). Vector and Tensor Analysis with Applications. By AI Borisenko and IE Tarapov. Translated from the third Russian edition and edited by RA Silverman, Prentice-Hall.
3. Kay, D. C. (2011). Tensor Analysis. Schaum Series, McGraw Hills.

Mapping of Course Outcomes to Program Outcomes

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CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Theory of Equations**
Course Code	**:**	**MTHC18**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course explores the fundamental and advanced aspects of polynomial equations, including their properties, solutions, and applications. Topics include the fundamental theorem of algebra, roots and coefficients relations, symmetric functions of roots, transformations of equations, and various methods for solving algebraic equations. Students will analyze the behavior of polynomials and study numerical techniques for root approximation.

Course Objectives:

1. To Establish relations between roots and coefficients.
2. To Apply transformations to simplify equations.
3. To Analyze and classify roots of equations.
4. To Solve polynomial equations using algebraic and numerical methods.

Pre-requisite:
Basic knowledge of algebra, polynomials, and mathematical analysis.

Course Outcome: On successful completion of the course, the students will be able to

CO1: Analyze the fundamental properties of polynomials and their graphical behavior.
- ILO 1.1: Explain the general properties of polynomials and their graphical representations.
- ILO 1.2: Determine the maximum and minimum values of polynomials.
- ILO 1.3: Apply Descartes' rule of signs to determine the number of positive and negative roots.
- ILO 1.4: Establish relationships between the roots and coefficients of polynomial equations.

CO2: Apply symmetric functions and transformations to solve polynomial equations.
- ILO 2.1: Define symmetric functions of roots and their applications in solving equations.
- ILO 2.2: Transform polynomial equations to simplify their solutions.
- ILO 2.3: Solve reciprocal and binomial equations using algebraic techniques.
- ILO 2.4: Derive and apply algebraic solutions for cubic and biquadratic equations.
- ILO 2.5: Analyze the properties of derived functions of polynomials.

CO3: Utilize symmetric functions and Newton's theorem to analyze polynomial roots.
- ILO 3.1: Apply Newton's theorem to compute sums of powers of roots.
- ILO 3.2: Use homogeneous products in polynomial equations.
- ILO 3.3: Determine the limits of the roots of polynomial equations.

CO4: Implement root separation techniques and numerical methods to solve equations.
- ILO 4.1: Apply Sturm's theorem to separate and analyze the roots of equations.

- ILO 4.2: Use Sturm's theorem to determine the number of real roots of a polynomial.
- ILO 4.3: Establish conditions for the reality of roots in polynomial and biquadratic equations.
- ILO 4.4: Solve numerical equations using analytical and computational techniques.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE						
CONCEPTUAL KNOWLEDGE			CO1 CO2			
PROCEDURAL KNOWLEDGE			CO3 CO4	CO1 CO2		
METACOGNITIVE KNOWLEDGE						

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I **(15 Marks)**	General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations	12	04	-	16
II **(15 Marks)**	Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions	12	04	-	16
III **(15 Marks)**	Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.	09	03	-	12
IV **(15 Marks)**	Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics

- Assignment
- Group Discussion
- Quiz
- Viva-Voce

TEXTBOOKS:

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press,1954.

2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc.,1954.

Mapping of Course Outcomes to Program Outcomes

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CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Advanced Mathematical Logic**
Course Code	**:**	**MINMTH7**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides a rigorous introduction to formal logic, covering propositional and predicate logic, proof techniques, and undecidability. Students will explore the syntax and semantics of logical systems, inference rules, and formal proof methods. The course also introduces foundational concepts in computability, including Gödel's Incompleteness Theorems and Church's Theorem, to examine the limits of formal systems.

Prerequisites:

Students are expected to have a foundational understanding of:

- Basic mathematical reasoning and proof-writing techniques.
- Set theory, functions, and relations.

Course Objectives:

1. To Understand and apply the principles of propositional and predicate logic.
2. To Construct truth tables, identify tautologies, and manipulate logical expressions using normal forms.
3. To Use proof techniques such as direct proof, contradiction, and formal proof systems to establish logical conclusions.
4. To Analyze and apply rules of inference for deductive reasoning.
5. To Understand fundamental undecidability results, including Gödel's Incompleteness Theorems and Church's Theorem.
6. To Develop an appreciation for the role of logic in mathematical reasoning, computation, and formal verification.

Course Outcome:

On successful completion of the course, the students will be able to

CO1: Demonstrate an understanding of propositional logic, its syntax, semantics, and proof techniques.

ILO 1.1: Define and explain the syntax and semantics of propositional logic, including logical connectives, truth tables, and tautologies.

ILO 1.2: Construct and verify logical arguments using truth tables, logical equivalences, and normal forms (CNF, DNF) to establish tautologies and valid reasoning.

CO2: Apply predicate logic and quantifiers to formal reasoning and theorem proving.

ILO 2.1: Identify and explain the syntax and semantics of predicate logic, quantifiers, bound and free variables, and logical interpretations.

ILO 2.2: Formulate and prove logical statements using predicate logic, applying rules of inference, prenex normal forms, and the Adequacy Theorem.

CO3: Use various proof techniques, such as direct proof, proof by contradiction, and inference rules, to establish logical conclusions.

ILO 3.1: Explain and differentiate between proof techniques such as direct proof, proof by contradiction, and proof by contraposition, along with rules of inference.

ILO 3.2: Apply appropriate proof techniques to verify logical statements, construct formal proofs, and justify their correctness.

CO4: Analyze undecidability, Gödel's incompleteness theorem, and recursive functions in formal logic.

ILO 4.1: Explain the concepts of undecidability, recursive functions, and Gödel numbering, including their implications in mathematical logic.

ILO 4.2: Analyze Gödel's incompleteness theorem, Church's theorem, to determine their impact on the limits of formal mathematical systems.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL		CO1				
CONCEPTUAL		CO2; CO3; CO4				CO1
PROCEDURAL			CO2; CO3	CO4		
METACOGNITIVE						

UNITS	CONTENTS	L	T	P	Total Hours
I (14 Marks)	**Propositional Logic:** Syntax and semantics of propositional logic, Logical connectives: Conjunction, Disjunction, Negation, Implication, and Biconditional, Truth tables and tautologies, Logical equivalences and normal forms (CNF, DNF), Adequate Sets of Connectives, Propositional proof systems: Axiomatic systems and semantic tableaux	09	03	-	12
II (18 Marks)	**Predicate Logic and Quantifiers** The formal system L, The Adequancy Theorem for L, Syntax and semantics of Predicate logic, Universal Quantifier (∀) and existential quantifier (∃), Bound and free variables, substitution, and interpretations, Logical consequence and Validity, The formal system K, Prenex form, The Adequancy Theorem for K, Models	15	05	-	20
III (14 Marks)	**Proof Techniques and Inference Theory** Method of proof: Direct, indirect, proof by contradiction, Rules of Inference: Modus Ponens, Modus Tollens, Universal Instantiation, Universal Generalization, Formal proof systems: Natural deduction and Hilbert-style proofs, Resolution theorem proving, Inference Theory: Deductive and Inductive reasoning, logical inference	12	04		16
IV (14 Marks)	**Undecidability** Natural Numbers with Successor, Other Reducts of Number Theory, A Subtheory of Number Theory, Arithmetization: Godel Number, Incompleteness and Undecidability, Recursive Functions, The fixed-point theorem: Godel's Incompleteness Theorem, Recursive Undecidability: Church's Theorem, Non Standard Models.	09	03	-	12
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Elliot Medelson, Introduction to Mathematical Logic, CRC Press, 2015

2. Herbert B. Enderton, A Mathematical Introdution to Logic, Academic Press, 2001.

3. A. G. Hamilton, Logic for Mathematicians, Cambridge University Press, 1988.

REFERENCE BOOKS:

1. Ian Chiswell and Wilfried Hodges, Mathematical Logic, Oxford University Press, 2007
2. Michael Huth & Mark Ryan, Logic in Computer Science, Cambridge University Press, 2004.

Mapping of Course Outcomes to Program Outcomes:
This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Research Methodology**
Course Code	**:**	**MTH7RM**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=0, P=1)**
Distribution of Marks	**:**	**45 (End Sem) + 15(Practical) + 40 (In-Sem)**

Course Description:

This course provides an in-depth understanding of research methodology in mathematics. It covers fundamental aspects of mathematical research, including research methods, ethical considerations, and publication practices. The course emphasizes the process of organizing and writing mathematical research papers, preparing for presentations, and utilizing manuscript preparation tools such as LaTeX. Additionally, it introduces students to essential software for mathematical computations along with research and publication ethics, plagiarism with the issue of similarity, ensuring integrity and quality in research.

Course Objectives:

1. To introduce students to the fundamentals of mathematical research and the various methodologies used in mathematical investigations.
2. To develop skills for organizing and writing mathematical research papers, including formulating theorems, proofs, abstracts, and bibliographies.
3. To understand ethical considerations in research, including scientific integrity, plagiarism, and publication ethics.
4. To familiarize students with indexing databases, citation metrics, and open-access publishing.
5. To provide hands-on experience with manuscript preparation tools such as LaTeX, as well as plagiarism detection and grammar-checking software.
6. To equip students with knowledge of computational software like Mathematica, Matlab, and Maple for solving mathematical problems.
7. To prepare students for effective research communication through seminars, project proposals, and journal submissions.

Course Objective:

On successful completion of the course, the students will be able to

CO1: Develop an understanding of the fundamentals of mathematical research, including various methodologies and techniques for conducting research in mathematics.

ILO 1.1: Explain the basic issues and avenues of mathematical research.

ILO 1.2: Identify and compare different research methodologies used in mathematics.

ILO 1.3: Apply appropriate research methods for various mathematical problems.

CO2: Acquire the skills necessary to prepare and organize a mathematical research paper, including structuring theorems, remarks, proofs, abstracts, bibliographies, and literature reviews.

ILO 2.1: Organize and structure a mathematical research paper effectively.

ILO 2.2: Develop skills to write mathematical statements, including theorems, remarks, and proofs.

ILO 2.3: Prepare research abstracts, bibliographies, and synopsis reports in a structured manner.

CO3: Understand and utilize ethical considerations in research, including intellectual honesty, integrity, and misconduct such as plagiarism, falsification, and fabrication.

ILO 3.1: Explain the ethical principles related to scientific research and moral philosophy.

ILO 3.2: Identify and analyze different types of scientific misconduct, including falsification and plagiarism.

ILO 3.3: Evaluate and apply ethical guidelines to maintain research integrity.

CO4: Understand and utilize the knowledge about publication ethics, including responsibilities of authors, indexing databases, citation metrics, and the significance of open-access publications.

ILO 4.1: Describe the importance of publication ethics in research.

ILO 4.2: Differentiate between various research metrics and indexing databases.

ILO 4.3: Apply ethical principles while preparing and submitting research articles.

CO5: Learn to use various manuscript preparation software and mathematical tools such as LaTeX, plagiarism detection software, grammar-checking tools, and mathematical computation software.

ILO 5.1: Utilize LaTeX for mathematical manuscript preparation.

ILO 5.2: Apply plagiarism detection, grammar checking, and journal finder tools for research enhancement.

ILO 5.3: Use mathematical software (Mathematica, Matlab, Maple) to solve mathematical problems efficiently.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL		CO1; CO3				CO1; CO2
CONCEPTUAL		CO4			CO3	CO2
PROCEDURAL			CO1;CO4; CO5	CO2;CO3		
METACOGNITIVE						

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	**Fundamentals of Mathematical Research:** Basic issues of Mathematics, objects and avenues of Mathematical research methodology of Mathematical research, various methods adopted for doing research in Mathematics.	10	-	-	10
II (15 Marks)	**Preparation of Mathematical Research:** How to organize a paper, How to write a mathematical statement viz. theorem, remark, proof etc. how to write Abstract and Bibliography, Review of Literature, Preparation of a talk and seminar paper, Preparation of a synopsis/ project.	15	-	-	15
III (10 Marks)	**Scientific Conduct:** Ethics: definition, moral philosophy, nature of moral philosophy and reactions, Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication and Plagiarism; Redundant Publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data.	10	-	-	10
IV (10 Marks)	**Publication ethics:** Definition, introduction and importance; Responsibility of Corresponding author and co-authors of research article; Relevance of acknowledgement component in a research article; conflicts of interest; violation of publication ethics, authorship and contributorship; Indexing databases; Citation databases; Research Metrics; Open access publications and initiatives; Publication misconduct, Predatory publishers and journals.	10	-	-	10
V (15 Marks)	**Computer Applications:** **Manuscript Preparation Software for Mathematical Symbols Content**: Latex: Use of Latex, Preparation of a manuscript using Latex (Research Paper and Seminar presentation). Plagiarism software: Turnitin; Drillbit and other open source software tools. Paraphrasing and grammar checking software: QuillBot; Grammarly and other open source software tools. Journal finder tools: JANE, Elsevier Journal Finder, Springer Journal finder etc; **Utility of Software in Mathematical Research:** Mathematica, Matlab, Maple for obtaining solutions for various Mathematical problems.			30	30
	Total	45	-	30	75

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**

- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. C. R. Kothari, G. Garg, Research Methodology: Methods and Technique, New Age International Publishers, 2019.
2. S. G. Krantz, A Primer of Mathematical Writings, University Press.
3. N. J. Higham, Handbook of writing of Mathematical Sciences, SIAM, Philadelphia, Pensylvenia, 1993.
2. A. Mac Intyre, A Short History of Ethics, London(1967).
4. P.Chaddash, Ethics in Competitive Research: Do not get scooped; do not get plagiarized, 2018.
5. NAS, NASEIM, On being scientists: A guide to responsible being conduct to research, third Edition National Acedemic Press. (2009).
6. S. Loue, Textbook of Research Ethics Theory and Practice Compress, Kluwar Academic Publishers, 2002. https://link.springer.com/book/10.1007/b112315

REFERENCE BOOKS:

1. A. Bird, Philosophy of Sciences, Routledge, (2006).

2. D.B. Rensik, what is ethics in research and why is important, NIEHS (2011) https://www.niehs.nih.gov/research/resources/bioethics/whatis

3. J. Beall, Predatory Publishers are corrupting open access, Nature, 2012.
4. K. Murlidhar, A. Ghosh, A. K. Singhvi, Ethics in Science Education, Research and Govornance, INSA, New Delhi. https://www.insaindia.res.in/pdf/Ethics_Book.pdf

Mapping of Course Outcomes to Program Outcomes:
This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low (‘Low’) contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	S	M	M
CO2	S	S	S	S	S	S	S	S	M	M
CO3	S	S	S	S	S	S	S	S	M	M
CO4	S	S	S	S	S	S	S	S	M	M
CO5	S	S	S	S	S	S	S	S	M	M

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Functional Analysis**
Course Code	**:**	**MTHC-19**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Functional analysis is a discipline of mathematical analysis that deals with vector spaces endowed with limit-related structures, as well as linear operators acting on these spaces. It applies concepts from linear algebra and calculus to infinite-dimensional spaces, frequently employing tools from topology and measure theory. Key subjects include normed spaces, Banach and Hilbert spaces, bounded linear operators, fixed point theory and its applications to differential and integral equations. Functional analysis provides essential frameworks for quantum mechanics, solutions of nonlinear equations and many other fields of pure and applied mathematics, with a focus on the study of function spaces and transformations.

Pre-Requisites:

- Introduction to Real Analysis.
- Introduction to Linear Algebra and Metric spaces.
- Basic concepts of Topology.
- Basic Concepts of differential and integral equations.

COURSE OBJECTIVE:

1. To develop a thorough understanding of the fundamental ideas of functional analysis, such as linear operators, normed spaces, Banach spaces, and Hilbert spaces.

2. To enhance problem-solving abilities by tackling challenging functional analysis proofs and issues.

3. To determine how functional analysis relates to other mathematical fields like measure theory, topology, and mathematical physics.

4. To strengthen critical thinking and abstract reasoning abilities through rigorous proof-based learning.

5. To improve the ability to effectively express mathematical concepts and conclusions, both in writing and vocally.

6. To build the capacity to make contributions to the field by preparing for advanced study and research in functional analysis and associated fields.

COURSE OUTCOME:

After going through this course, the students will be able to

CO1: Demonstrate the concept of normed spaces, Banach spaces, Hilbert spaces, and the properties of linear operators.

ILO1: Identify the basic definitions and distinctions between normed spaces, Banach spaces, and Hilbert spaces.

ILO2: Provide specific examples and explain why they fit the definitions of normed spaces, Banach spaces, and Hilbert spaces.

ILO3: Discuss the key properties and types of linear operators (bounded, unbounded, compact, etc.) in the context of normed, Banach, and Hilbert spaces.

ILO4: Investigate and describe the types of convergence (norm convergence, weak convergence, strong convergence) in normed, Banach, and Hilbert spaces.

ILO5: Demonstrate the significance of completeness in Banach and Hilbert spaces by solving related problems and proving related theorems.

CO2: Explain and interpret fundamental theorems such as the Hanh-Banach theorem, Closed Graph theorem, Open Mapping theorem and Uniform Boundedness of functional analysis to solve theoretical problems.

ILO 1: Present a detailed proof of the Hahn-Banach theorem and discuss its implications in functional analysis.

ILO2: Interpret the Closed Graph theorem and illustrate its use in identifying properties of linear operators.

ILO3: Show how the Open Mapping theorem is used in functional analysis through examples.

ILO4: Explain the Uniform Boundedness principle and solve problems that utilize this theorem.

CO3: Apply functional analysis theorems and techniques to solve functional equations, including differential and integral equations.

ILO1: Apply theorems from functional analysis to find solutions to differential equations.

ILO2: Utilize techniques from functional analysis to address and solve integral equations.

ILO3: Implement concepts from Banach and Hilbert spaces to find solutions to various functional equations.

ILO4: Use fixed-point theorems such as Banach's Fixed Point Theorem to solve functional equations.

CO4: Analyze the properties and effectiveness of adjoint bounded linear operators, orthogonal and orthonormal sets and sequences, Legendre, Hermite, and Laguerre polynomials, and Riesz's representation theorem in Hilbert spaces.

ILO1: Analyze the definition, properties, and applications of adjoint operators in Hilbert spaces.

ILO2: Discuss the significance of orthogonal and orthonormal sets and sequences in Hilbert spaces and their applications.

ILO3: Use Riesz's representation theorem to solve problems and illustrate its implications in Hilbert spaces.

ILO4: Investigate the properties and applications of Legendre, Hermite, and Laguerre polynomials within the framework of functional analysis.

ILO5: Apply orthogonal polynomials to practical problems in Hilbert spaces and analyze their effectiveness.

CO5: Use techniques from functional analysis to investigate multidisciplinary applications in quantum physics, measure theory, topology, and other scientific areas.

ILO1: Use concepts from functional analysis to solve problems in quantum mechanics, such as the study of operators on Hilbert spaces.

ILO2: Demonstrate how measure theory can be combined with functional analysis to solve advanced mathematical problems.

ILO3: Discuss the role of functional analysis in topological spaces and its applications in various branches of mathematics.

ILO4: Apply functional analysis to solve problems in different mathematical issues.

Cognitive Map of Course Outcomes with Bloom's Taxonomy:
This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE		CO2	CO1, CO3	CO5		
CONCEPTUAL KNOWLEDGE		CO2	CO1, CO3,	CO4		

			CO5			
PROCEDURAL KNOWLEDGE		CO2	CO1, CO3	CO4		
METACOGNITIVE KNOWLEDGE		CO2		CO4		

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	**Normed and Banach spaces:** Definitions, examples and basic properties of Normed spaces and Banach spaces. Subspace, Compactness and finite dimension, Definitions, examples and basic properties of Bounded linear operators and functionals, Dual space.	12	04	-	16
II (15 Marks)	**Fundamental theorems for Normed and Banach Spaces:** Open mapping theorem and its consequences, Closed graph theorem and its consequences, Uniform boundedness principal. Hanh-Banach Theorem and its consequences. Adjoint of bounded linear operator.	12	04	-	16
III (15 Marks)	**Hilbert Spaces:** Definitions, example and basic properties of inner-product spaces and Hilbert spaces, Orthogonal Complements and direct sums, Orthogonal sets and sequences, Series related to Orthonormal sequences and sets, Total orthonormal sets. Legendre, Hermite and Laguerre polynomials, Riesz's representation theorem. Hilbert -Adjoint operator, Self Adjoint operator.	12	04	-	16
IV (15 Marks)	**Some Applications:** Banach fixed point theorem and its applications to Linear Equations, Differential Equations and Integral Equations. Multiplication and Differential Operator in Quantum Mechanics.	09	03	-	12
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**

- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Jain, P. K., Ahuja, O. P., Ahmed, K. (1995). Functional Analysis. New Age International (P) Limited.
2. Kreyszig, E. (1978). Introductory functional analysis with applications. New York: Wiley.
3. Limaye, B. V. (2014). Functional Analysis. New Age International P Ltd.

REFERENCE BOOKS:

1. Ponnusamy, S. (2002). Foundations of functional analysis. CRC Press.
2. Choudhary, B., Nanda, S. (1989). Functional analysis with applications. Wiley.

Mapping of Course Outcomes to Program Outcomes:
This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low ('Low') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Non-Linear Dynamical System and Chaos**
Course Code	**:**	**MTHC20**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on **Nonlinear Dynamical Systems and Chaos** discusses one- and two-dimensional flows and bifurcations and a brief idea about chaos

Course Objective:

The objective of this course is to introduce

(i) Flow on a line and bifurcation in one dimensional flows
(ii) Classification of linear and nonlinear system, limit cycles
(iii) One dimensional maps, fractals and chaos

Course Outcomes:

On successful completion of the course, the students will be able to

CO1: explain basics of fixed points and stability

ILO 1.1: Evaluate fixed points.

ILO 1.2: Determine the stability of fixed points.

CO2: Distinguish various types of bifurcations in one dimension

ILO 2.1: Sketch bifurcation diagrams of one dimension.

ILO 2.1: analyse the stability of bifurcation diagram.

CO3: Classification of linear systems and analysis of two dimensional bifurcations

ILO 3.1: Discuss structural stability of two dimensional bifurcations

ILO 3.2. Classify bifurcations in higher dimensions.

CO4: describe chaos

ILO 4.1: find attractors and domain of attraction

ILO 4.2: Construct Mandelbrot set by defining its method of construction.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge	CO1			CO2		CO4
Procedural Knowledge	CO3	CO1			CO4	
Metacognitive Knowledge						

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I **(15 Marks)**	**One Dimensional Flows and Bifurcations:** Introduction, Fixed points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of oscillations, Saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Imperfect bifurcations, Flow on the circle.	12	04	-	16
II **(18 Marks)**	**Two Dimensional Flows and Bifurcations:** Linear Systems: Definition, examples and classification of linear systems, Phase planes: Introduction, phase portraits, conservative systems, Reversible systems, Index theory, Limit cycles: Introduction and examples, Ruling out closed orbits, Liapunov Functions, Poincare-Bendixson, theorem, Lienard Systems, Relaxation Oscillators, Weakly non-linear oscillators, Saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Hopf bifurcation,	12	04	-	16
III **(Marks 15)**	**Chaos:** Lorenz Equations: Introduction, Simple properties of the Lorenz equation, Definitions of chaos, attractors and strange attractors, One dimensional maps: Introduction, Fixed points and Cobwebs, Numeric and analysis of Logistic map, Renormalization	12	04	-	16

IV **(Marks 12)**	**Fractals:** Countable and uncountable sets, Cantor set and its fractal property, Dimensions of self similar fractals, Box Dimension, The von Koch curve, Strange attractors	09	03	-	12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Strogatz, S. H. (2018). Nonlinear Dynamics and Chaos with Student Solutions Manual: With Applications to Physics, Biology, Chemistry, and Engineering. CRC Press.
2. Kaplan, D., Glass, L. (2012). Understanding nonlinear dynamics. Springer Science & Business Media.

REFERENCE BOOKS:

1 Thompson, J. M. T., Thompson, M., Stewart, H. B. (2002). Nonlinear dynamics and chaos. John Wiley & Sons.

2. Devaney, R., (2003) An Introduction to Chaotic dynamical systems., West-view Press.

Mapping of Course Outcome to Program Outcome

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	M	S
CO2	S	S	M	M	L	M	M	M	M	S
CO3	S	S	M	M	L	M	M	M	M	S
CO4	S	S	M	M	L	M	M	M	M	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Dissertation**
Course Code	**:**	**MTH8D**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**08**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Finite Element Methods**
Course Code	**:**	**MTH8D1**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVE:

The objectives of this course are to:

- Introduce the fundamental concepts of the finite element method (FEM) and its mathematical formulation.
- Develop and apply weighted residual methods and variational formulations for boundary value problems.
- Implement finite element techniques for solving ordinary and partial differential equations in one, two, and three dimensions.
- Understand element types, interpolation functions, numerical integration, and modeling considerations in FEM.

Course Outcome:

On successful completion of the course, the students will be able to:

CO1: Understand the fundamental concepts and analyze mathematical formulations of finite element methods (FEM).

- **ILO1.1:** Explain the basic principles and significance of finite element methods in numerical analysis.
- **ILO1.2:** Analyze different methods of weighted residuals, including collocation, least squares, and Galerkin methods.
- **ILO1.3:** Formulate boundary value problems using variational methods and establish the equivalence of Galerkin and Ritz methods.

CO2: Apply finite element methods to solve ordinary differential equations (ODEs).

- **ILO2.1:** Develop finite element formulations for solving simple ODEs.
- **ILO2.2:** Implement FEM techniques for solving boundary value problems involving ODEs.

CO3: Understand and implement linear, quadratic, and higher-order elements in one-dimensional problems.

- **ILO3.1:** Construct finite element approximations using linear and higher-order shape functions.
- **ILO3.2:** Assemble and solve FEM systems for one-dimensional problems.

- **ILO3.3:** Analyze the effect of element order on the accuracy of the solution.

CO4: Extend finite element methods to two and three dimensional problems using simplex and quadrilateral elements.

- **ILO4.1:** Define and apply interpolation functions for triangular and rectangular elements.
- **ILO4.2:** Perform numerical integration for FEM formulations in two and three dimensions.

CO5: Solve two-dimensional partial differential equations (PDEs) using finite element methods.

- **ILO5.1:** Develop FEM formulations for solving PDEs under different geometric conditions.
- **ILO5.2:** Implement computational methods for solving PDEs using FEM techniques.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge		CO1; CO3		CO4		CO2; CO5
Procedural Knowledge			CO2; CO3 CO4; CO5	CO1		
Metacognitive Knowledge						

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I **(18 Marks)**	Introduction to finite element methods, Methods of weighted residuals, collocations, least squares and Galerkin's method. Variational formulation of boundary value problems. Equivalence of Galerkin and Ritz methods.	15	05	-	20
II **(10 Marks)**	Applications to solving simple problems of ordinary differential equations.	06	02	-	08

III **(10 Marks)**	Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.	09	03	-	12
IV **(12 Marks)**	Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements. Interpolation functions, numerical integration, and modeling considerations**.**	09	03	-	12
V **(10 Marks)**	Solution of two dimensional partial differential equations under different Geometric conditions.	06	02		08
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. J.N. Reddy, *Introduction to the Finite Element Methods*, Tata McGraw-Hill,2003.
2. K.J. Bathe, *Finite Element Procedures*, Prentice-Hall,2001**.**
3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons,2002.

4. T. J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication,2000.

5. G. R. Buchanan, *Finite Element Analysis*, McGraw Hill,1994.

Mapping of Course Outcome to Program Outcome

CO/PO	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	S	S	M
CO2	S	S	M	M	L	M	M	S	S	M
CO3	S	S	M	M	L	M	M	S	S	M
CO4	S	S	M	M	L	M	M	S	S	M
CO5	S	S	M	M	L	M	M	S	S	M

S= Strong, M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Fluid Dynamics**
Course Code	**:**	**MTH8D2**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Fluid Dynamics deals with the basics of kinematics of fluid motion, stress and strain rate relation and its application on fluid flow. It also contains the motion of viscous fluid flow and its exact solution under some special cases.

Prerequisites:

- Vector calculus
- Complex analysis

Course Objective:

The course on fluid dynamics is designed for the students to gather basic knowledge of stress and strain and their application in fluid flow problems. Learners will be able to formulate the viscous fluid flow problems and solve them using some special cases.

Course outcomes: After completing the course a learner will be able to

CO1: Understand the concept of Stress and Strains and their relations.

ILO 1.1: Evaluate various stresses acting at a point on a surface.
ILO 1.2: Formulate the equation of motion of viscous fluid flow.

CO2: Construct Navier-Stokes equation in various coordinate systems

ILO 2.1: Establish the formula for energy dissipation due to viscosity.
ILO 2.2: Discuss various types of viscosities and give their significance.

CO3: Evaluate the exact solutions of Navier-Stokes equation

ILO 3.1: Analysis the behaviour of Couette flow solving Navier-Stokes equations.
ILO 3.2: Construct the solution of Navier-Stokes equation of unsteady viscous fluid flow.

CO4: Understand the concept of formation of boundary layer and its separation.

ILO 4.1: construct two dimensional boundary layer equations and its similarity form
ILO 4.2: Establish the relation between boundary layer thickness and shear stress and it's applications.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	**COGNITIVE PROCESS DIMENSION**					
	REMEMBERING	**UNDERSTANDING**	**APPLY**	**ANALYZE**	**EVALUATE**	**CREATE**

FACTUAL	**X**	**X**	**X**	**X**	**X**	**X**
CONCEPTUAL	**X**	**CO1, CO4**	**X**	**X**	**X**	**CO1,CO3**
PROCEDURAL	**X**	**X**	**X**	**CO3**	**CO1**	**CO4**
METACOGNITIVE	**X**	**CO2**	**CO2**	**X**	**X**	**X**

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I **(18 Marks)**	**Kinematics of Fluids in motion & Stress and Strain Analysis:** strain and its types, small deformation theory, stress vector and stress tensor, various stresses, constitutive equations, conservation laws and mathematical forms	15	03	-	18
II **(10 Marks)**	**Equations of motion of viscous fluid flows and properties:** Navier Stokes Equations , rate of change of circulation, diffusion of vorticity, vorticity equation and energy dissipation due to viscosity.	09	03	-	12
III **(16 Marks)**	**Exact Solutions of Navier Stokes equations:** Navier-Stokes equations, exact solutions of Navier-Stokes equations: Couette flow, Poiseuille flow, Hagen-Poiesuille flow through a pipe, flow through the annular region, Stokes first problem..	12	03	-	15
IV **(16 Marks)**	**Boundary Layer Theory:** Laminar boundary layer, two-dimensional boundary layer equations, Blasius equation, boundary layer parameters, separation of boundary layer, momentum and energy integral equation.	12	03	-	15
	Total	**48**	**12**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics

- Assignment
- Group Discussion
- Quiz
- Viva-Voce

TEXTBOOKS:

1. Chatterjee, R. (2015). Mathematical Theory of Continuum Mechanics. Narosa Publishing House.
2. 2. Schlichting, H., Gersten, K. (2016). Boundary-layer theory. Springer.
3. 3. Chorlton, F. (2004). Textbook of fluid dynamics. CBS Publisher.

REFERENCE BOOKS:

1. Spencer, A. J. M. (2004). Continuum Mechanics. Dover Publications.
2. Raisinghania, M. D. (2003). Fluid Dynamics. S. Chand Publications.
3. Lamb, S. R. (1945). Hydrodynamics. Dover Publications.
4. Ramsay, A. S. (1913). Hydrodynamics (A Treatise on Hydromechanics).
5. G. Bell and Sons, ltd.5. Kundu, P.K. Cohen, I. M., Dowling, D. R. (2011). Fluid Mechanics. Academic Press.
6. Thomson, L. M. M. (2011). Theoretical Hydrodynamics. Dover Publications

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	L	M	S	S
CO2	S	S	M	M	L	S	M	S	S	S
CO3	S	S	M	M	L	M	L	M	S	S
CO4	S	S	M	M	L	M	L	M	S	S

S= Strong. M= Medium, L= Low

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Information Security**
Course Code	**:**	**MTH8D3**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course explores the fundamental principles of information security with a focus on mathematical concepts. Topics include cryptographic techniques, number theory, probability, and algorithms essential for secure communication. Students will analyze encryption methods, hashing functions, and error detection techniques used to protect data integrity and confidentiality.

Pre-requisites:
Number Theory
Probability

Course Objectives:

1. To Apply cryptographic techniques for data protection.
2. To Analyze encryption algorithms and their security implications.
3. To Explore number theory and its role in cryptography.
4. To Develop problem-solving skills in secure data transmission and authentication.
5. To Assess security vulnerabilities using mathematical models.

Course Outcomes: On successful completion of the course, the students will be able to

CO1: Understand and analyze fundamental concepts of information security and authentication mechanisms.

ILO 1.1: Differentiate between protection and security.
ILO 1.2: Explain key aspects of security, including data integrity, availability, and privacy.
ILO 1.3: Identify security problems and user authentication techniques.
ILO 1.4: Analyze the role of the Orange Book in security evaluation.

CO2: Analyze various security threats and their impact on systems and communication.

ILO 2.1: Classify different types of program threats such as worms, viruses, Trojan horses, and buffer overflow.
ILO 2.2: Examine system threats like intruders and their attack strategies.
ILO 2.3: Identify communication threats, including tapping and piracy, and propose countermeasures.

CO3: Apply cryptographic techniques to ensure secure data communication.

ILO 3.1: Explain substitution and transposition ciphers and their applications.
ILO 3.2: Implement symmetric-key algorithms such as DES and AES.
ILO 3.3: Utilize public-key encryption methods including RSA, Diffie-Hellman, and ECC cryptography.

ILO 3.4: Apply message authentication techniques like MAC and hash functions for data integrity.

CO4: Evaluate and implement digital signature techniques for authentication.
ILO 4.1: Differentiate between symmetric and public-key digital signatures.
ILO 4.2: Explain the concept of message digests and their role in digital signatures.
ILO 4.3: Analyze the structure and functionality of public key infrastructures (PKI).

CO5: Implement security mechanisms to detect and prevent intrusions.
ILO 5.1: Explain intrusion detection techniques and their importance.
ILO 5.2: Utilize auditing and logging mechanisms for system security.
ILO 5.3: Analyze security tools like Tripwire and system call monitoring for threat detection.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1; CO2; CO3	CO4 CO5			
Procedural Knowledge			CO3	CO1; CO2; CO4; CO5		
Metacognitive Knowledge						

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (11 Marks)	Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book.	09	03	-	12
II (16 Marks)	Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.	12	04	-	16
III (11 Marks)	Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; Diffie- Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.	09	03		12
IV (11 Marks)	Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.	09	03	-	12
V (11 Marks)	Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system call monitoring.	06	02		08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. W. Stallings, *Cryptography and Network Security Principles and Practices,* 4th Ed., Prentice-Hall of

India, 2006.

2. C. Pfleeger and S.L. Pfleeger, *Security in Computing* ,3rd Ed., Prentice-Hall of India, 2007.

3. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.

4. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security*, Springer- Verlag

Berlin, 2003.

5. J.M. Kizza, *Computer Network Security*, Springer,2007.

6. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices*, Pearson

Education,2006.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong'), moderate ('Medium') and low (‘Low’) contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	S	S
CO2	S	S	M	M	L	M	M	M	S	S
CO3	S	S	M	M	L	M	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	M	M	M	S	S

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Fuzzy Set Theory**
Course Code	**:**	**MTH8D4**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course offers an in-depth exploration of fuzzy logic principles and their application in real-world scenarios. Focusing on the mathematical underpinnings of fuzzy sets, operations, and relations, alongside their use in systems modelling and decision-making, prepares students to effectively apply fuzzy logic in diverse fields such as engineering, artificial intelligence, and operations research.

Prerequisites:

- Introduction to Set Theory
- Basic Calculus
- Introduction to Probability and Statistics
- Basic Programming Knowledge

Course Objectives:

1. To introduce the concepts and principles of fuzzy sets and fuzzy logic, enabling students to understand and articulate the foundational theories and mathematical principles underlying fuzzy systems.
2. To develop computational skills for handling operations involving fuzzy sets and fuzzy logic, including basic operations, arithmetic, and fuzzy relations, fostering practical skills in manipulating fuzzy data.
3. To enhance analytical skills in fuzzy systems analysis, encouraging students to dissect, examine, and interpret fuzzy relationships and logic to solve complex problems in mathematics and related fields.
4. To cultivate the ability to apply fuzzy logic to real-world problems, training students to utilize fuzzy sets in various applications such as decision-making, engineering, and data analysis, thereby improving their problem-solving skills.
5. To promote the synthesis of new knowledge by engaging students in designing and developing fuzzy inference systems, stimulating innovation and creativity in building advanced fuzzy models and applications.
6. To prepare students for further academic and professional pursuits in mathematics, engineering, computer science, and other disciplines where fuzzy logic provides a valuable framework for addressing uncertainty and imprecision.

Course Outcomes (Cos):

CO1: Interpret fuzzy sets accurately

ILO1: Describe uncertainty and basic fuzzy set concepts with examples.

ILO2: Interpret crispness and fuzziness accurately.

CO2: Perform essential operations such as alpha-cuts and convex fuzzy sets.

ILO1: Explain the Significance of alpha-cuts and convex fuzzy sets

ILO2: Perform operations involving alpha-cuts and convex fuzzy sets

CO3: Execute arithmetic operations on fuzzy numbers using interval arithmetic.

ILO1: Explain the Principles and Significance of Interval Arithmetic in Fuzzy Numbers

ILO2: Implement the Conceptual Framework of Arithmetic Operations on Fuzzy Numbers

CO4: Analyze fuzzy equivalence and ordering relations and their compositions.

ILO1: Explain the Principles of Fuzzy Equivalence and Ordering Relations

ILO2: Analyze the Conceptual Framework of Fuzzy Equivalence and Ordering Relations

CO5: Demonstrate fuzzy inference systems incorporating linguistic hedges and approximate reasoning.

ILO1: Interpret the Functioning and Importance of Linguistic Hedges and Approximate Reasoning in Fuzzy Inference Systems.

ILO2: Execute Linguistic Hedges and Approximate Reasoning in Developing Fuzzy Inference Systems

CO6: Execute fuzzy set theory to real-world problems, particularly decision-making.

ILO1: Summarize the procedure of the Application of Fuzzy Set Theory in Decision-Making

ILO2: Demonstrate the Conceptual Framework of Applying Fuzzy Set Theory to Decision-Making

CO7: Critically evaluate the outcomes.

ILO1: Analyze Evaluation Methods to Assess Outcomes in Fuzzy Set Theory Applications

ILO2: Critically Evaluate the Effectiveness of Fuzzy Set Theory Applications

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1	CO2			

Conceptual Knowledge			CO3	CO4		
Procedural Knowledge			CO5, CO6		CO7	
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I **(12 Marks)**	**Unit I: Basic of Fuzzy Sets:** Uncertainty, Taxonomy of Uncertainty, Motivation, Concepts of crispness and fuzziness, Fuzzy set and its representation, α- cut, convex fuzzy set, basic operations on fuzzy sets, types of fuzzy sets, extension principle, t-norm, t-conorms and their properties.	09	03	-	12
II **(12 Marks)**	**Unit II: Fuzzy Arithmetic and Method of Construction of Membership Function:** Fuzzy Numbers Types of Fuzzy numbers, Interval Arithmetic, Arithmetic operations on fuzzy numbers, membership function formulation.	09	03	-	12
III **(12 Marks)**	**Unit III: Fuzzy Relations:** Fuzzy relation, binary fuzzy relations, union and intersection of fuzzy relations, projection and cylindrical extensions, fuzzy equivalence relation, Fuzzy compatibility relations, Fuzzy ordering relations, compositions of fuzzy relations and their properties.	09	03	-	12
IV **(12 Marks)**	**Unit IV: Fuzzy logic and Fuzzy System:** Defuzzification, classic and fuzzy logic, approximate reasoning, linguistic hedges, fuzzy inference, fuzzy rule based system.	09	03	-	12
V **(12 Marks)**	**Unit-V: Uncertainty measure and Applications of Fuzzy sets:** Uncertainty based information, non-specificity of fuzzy set, fuzziness of fuzzy sets, Applications of fuzzy sets in decision making and other real world problems.	09	03	-	12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examinations of 10 marks each - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Klir, G. J., Yuan, B. (1995). Fuzzy sets and Fuzzy logic: theory and applications. New Jersey: Prentice Hall PTR.

2. Zimmermann, H. J. (2011). Fuzzy set theory and its applications. Springer Science & Business Media.

REFERENCE BOOKS:

1. Ross, T. J. (2005). Fuzzy logic with engineering applications. John Wiley & Sons.
2. Pedrycz, W., Gomide, F. (1998). An introduction to fuzzy sets: analysis and design. MIT Press.

Mapping of Course Outcomes to Program Outcomes

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CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	S	M	M	M
CO2	S	S	M	M	L	M	S	M	M	M
CO3	S	S	M	M	L	M	S	M	M	M
CO4	S	S	M	M	L	M	S	M	M	M
CO5	S	S	M	M	L	M	S	M	M	M
CO6	S	S	M	M	L	M	S	S	S	M
CO7	S	S	M	M	L	M	S	S	S	M

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Probability and Statistics**
Course Code	**:**	**MINMTH8**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an elementary introduction to probability and statistics with applications. Probability is the study of chance and is a very fundamental subject that we apply in everyday living, while statistics is more concerned with how we handle data using different analysis techniques and collection methods. Topics include mathematical expectation, moment generating function, Joint cumulative distribution function, Central Limit theorem, covariance, linear regression, Chebyshev's inequality.

Pre-Requisites:

- Understanding of probability theory.
- Basic concepts of calculus.
- Random experiment, Outcomes, Sample space, and Event.

Course Objectives:

The main objectives of this course is to provide students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science. This sets the stage for more advanced mathematical concepts and real-world applications. Its goals are to identify distributions, analyze data, and understand probability concepts.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Define the principal concepts about probability.

ILO1.1: Achieve a solid understanding of concept of random event.

ILO1.2: Express the features of discrete and continuous random variables.

ILO1.3: Formulate the distribution functions.

CO2: Understanding the fundamental concepts of a joint pmf, pdf and cdf of two random variables.

ILO2.1: Finding the frequency of occurrence of values for the given phenomena using cumulative frequency analysis.

ILO2.2: Able to compute probabilities and marginal from a joint pmf or pdf.

ILO2.3: Able to test whether two random variables are independent.

CO3: Understanding the difference between covariance and correlation.

ILO3.1: Used to determine if two variables are dependent on each other.

ILO3.2: Learn about the differences and similarities between covariance and correlation, and explore their applications.

ILO3.3: Analyze and widely used in various fields, including finance, economics, and science.

CO4: Investigate and illustrate the central limit theorem.

ILO4.1: Describe sampling distributions of the sample mean using the theorem.

ILO4.2: Calculate the standard deviation of sampling distributions using the theorem.

ILO4.3: Provides a solid foundation for performing hypothesis tests, making statistical estimates more reliable and accurate.

CO5: Joint cumulative distribution function helps to understand how to characterize the probability distribution of a random vector.

ILO5.1: Recognize the probability that two conditions are true simultaneously.

ILO5.2: Essential for various applications in statistics, such as hypothesis testing, confidence interval estimation, and data analysis.

ILO5.3: Fundamental concept in the field of statistics and probability theory.

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Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO4		CO5
Procedural Knowledge			CO1, CO2	CO3	CO4	CO5
Metacognitive Knowledge					CO5	CO4

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (18 Marks)	Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.	15	05	-	20
II (18 Marks)	Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient.	15	05	-	20
III (9 Marks)	Joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables (Matrix approach), Chebyshev's inequality.	03	01	-	04

IV (15 Marks)	Statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance.	12	04	-	16
	Total	45	15	-	60

where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

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- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

3. Ross S., First Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Mood A. M., Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.

REFERENCE BOOKS:

3. Hogg R. V., McKean J. W. and Craig A. T., Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
4. Miller I. and Miller M., Freund J. E., Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

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CO2	S	S	M	M	L	M	M	S	S	M
CO3	S	S	M	M	L	M	M	S	S	M
CO4	S	S	M	M	L	M	S	M	S	S
CO5	S	S	M	M	L	M	S	S	M	S