CHAITANYA SCIENCE AND ARTS COLLEGE

(AUTONOMOUS) PAMGARH,
JANJGIR-CHAMPA (C.G.)

ACCREDITED "A" GRADE BY NAAC

DEPARTMENT
OF
MATHEMATICS

COURSE CURRICULUM & MARKING SCHEME

POSTGRADUATE PROGRAMME

M.Sc. MATHEMATICS

PROGRAM CODE: **CCMS03**

FIRST & SECOND SEMESTER
& III, IV

Approved By	Board of Studies	Academic Council
Date	16/08/26	

ACADEMIC YEAR 2026-27

Website: https://chaitanyacg.ac.in/ **Email:**principalchaitanya417@gmail.com

16.08.2026

Scheme of M.Sc. Mathematics (Semester System)

Program Code: CCMS03

Semester	Course Code	Subject Name	Max Marks	Internal	Total Marks
First	MMAT101	Advanced Abstract Algebra - I	70	30	100
	MMAT102	Real Analysis - I	70	30	100
	MMAT103	Topology - I	70	30	100
	MMAT104	Complex Analysis - I	70	30	100
	MMAT105	Advanced Discrete Mathematics - I	70	30	100
Total (First)					**500**
Second	MMAT201	Advanced Abstract Algebra - II	70	30	100
	MMAT202	Real Analysis - II	70	30	100
	MMAT203	Topology - II	70	30	100
	MMAT204	Complex Analysis - II	70	30	100
	MMAT205	Advanced Discrete Mathematics - II	70	30	100
Total (Second)					**500**

NAME OF PROGRAM: M.Sc. Mathematics (CCMS03)

Program Outcomes: -

Program outcomes describe what students are expected to know or be able to do by the time of Post-Graduation. On completion of M.Sc. Mathematics program students will be able to-

1 . Understand fundamental axioms in Mathematics and capability of developing ideas based on them.

2. Develop proficiency in the analysis of complex physical problems and the use of mathematical or other appropriate technique to solve them.

3. Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.

4. Equip with skills to analyze problems, formulate a hypothesis, evaluate and validate results and draw reasonable conclusion thereof.

5. Gain advanced knowledge on topics in pure mathematics, empower to pursue higher degrees at reputed academic institutions.

6. Pursue research or careers in industry in mathematical sciences and allied fields.

7. Gain knowledge of a wide range of mathematical technique and application of mathematical methods/tools in other scientific and technological domains.

8. Gain advanced knowledge on topics in pure mathematics, empowering the students to pursue higher degrees at reputed academic institutions.

9. Gain strong foundation on Algebraic Topology and representation theory and good understanding o number theory which can be used in modern online cryptographic technologies.

10. Provide a systematic understanding of the concepts and theories of mathematics and their applications in the real world-to an advanced level, and enhance career prospects in a huge array of fields.

11. Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standard of ethical issues in mathematical sciences.

12. Select, interpret, and critically evaluate information from a range of sources that include books, scientific reports, journals, case studies and internet.

13. Recognize the needs to engage in lifelong learning through continuing education and research.

COURSE STRUCTURE:

The syllabus with the paper combination is as under:

SEMESTER-I

SR. NO.	COURSE CODE	TITLE OF COURSE
01.	MMAT101	Advanced Abstract Algebra - I
02.	MMAT102	Real Analysis - I
03.	MMAT103	Topology - I
04.	MMAT104	Complex Analysis - I
05.	MMAT105	Advanced Discrete Mathematics - I

SEMESTER -II

SR. NO.	COURSE CODE	TITLE OF COURSE
01.	MMAT201	Advanced Abstract Algebra - II
02.	MMAT202	Real Analysis - II
03.	MMAT203	Topology - II
04.	MMAT204	Complex Analysis - II
05.	MMAT205	Advanced Discrete Mathematics - II

SEMESTER -III

SR. NO.	COURSE CODE	TITLE OF COURSE
01.	MMAT301	Integration Theory and Functional Analysis -I
02.	MMAT302	Partial Differential Equations, Mechanics and Gravitation - I
OPTIONAL PAPER (ANY THREE)		
03.	MMAT303	Programming in C with ANSI Features- I
04.	MMAT304	Fuzzy Sets and their Applications-I
05.	MMAT305	Operations Research-I
06.	MMAT306	Fluid Mechanics-I
07.	MMAT307	Information Theory-I
08.	MMAT308	Fundamentals of Computer Science I

SEMESTER -IV

SR. NO.	COURSE CODE	TITLE OF COURSE
01.	MMAT401	Integration Theory and Functional Analysis -II
02.	MMAT402	Partial Differential Equations, Mechanics and Gravitation - II
OPTIONAL PAPER (ANY THREE)		
03.	MMAT403	Programming in C with ANSI Features- II
04.	MMAT404	Fuzzy Sets and their Applications-II
05.	MMAT405	Operations Research-II
06.	MMAT406	Fluid Mechanics-II
07.	MMAT407	Information Theory-II
08.	MMAT408	Fundamentals of Computer Science II

SEMESTER I

PROGRAMME	**M.SC. MATHEMATICS – I SEMESTER**
CORE COURSE	**COURSE CODE: MMAT101**
TITLE	**ADVANCED ABSTRACT ALGEBRA -1**
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**
Course Learning Objective	The end of this course, the students will be able to: Gain skills, of solving problems using powerful concepts of group action. Gain knowledge of Normal Series, Solvable groups, Nilpotent groups. Gain ability to deal with module theory which is indispensable in wide ranges of mathematical disciplines. Gain knowledge of Nilpotent and Nil ideals. Gain knowledge of representation and rank of linear mapping.

Unit	Description	No. of Lectures / Hours
I	Normal Series: Normal and subnormal series, Composition Series, Jordan–Hölder theorem, Solvable Group, Nilpotent Groups	15
II	Rings and Ideals: Maximal and Prime Ideals, Nilpotent and Nil Ideals	15
III	Modules: Definition and examples, Submodules, Quotient Modules, Direct Sums, Modules generated by a subset, Cyclic Module, Homomorphism of modules, Isomorphism Theorem, Exact sequence of modules, Simple modules, Semi-simple modules, Schur's lemma, Free module	15
IV	Field Theory: Extension fields, Algebraic and Transcendental extensions, Separable and Inseparable extensions, Normal extension, Perfect field, Finite fields, Primitive Elements	15

TEXT BOOKS:

Learning Resources

Reference Books

1. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul – *Basic Abstract Algebra*
2. I.N. Herstein – *Topics in Algebra*, Wiley Eastern Ltd., New Delhi (1975)
3. M. Artin – *Algebra*, Prentice Hall of India (1991)
4. D.S. Malik, J.N. Mordeson, and M.K. Sen – *Fundamentals of Abstract Algebra*, McGraw Hill International Edition (1997)

E-Resources

- NPTEL Online Courses
- e-PG Pathshala (INFLIBNET)
- SWAYAM

SEMESTER I

PROGRAMME	**M.SC. MATHEMATICS – I SEMESTER**
CORE COURSE	**COURSE CODE: MMAT102**
TITLE	**REAL ANALYSIS - I**
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**
Course Learning Objective (CLO)	The end of this course, the students will be able to: Gain the knowledge of Riemann-Stieltjeslntetgral, Sequence and Series of Functions, Power Series, Function of Several Variables. Gain the knowledge of Differentiability of Function in Several Variables and their relation to Partial Derivatives Develop competency to apply Implicit and Inverse Function Theorems and moving towards Calculus of Manifolds. Gain Knowledge of Riemann-Stieltjes Integral of Real Valued Function on Intervals ancL its extension to Complex and Vector-Valued Functions on Interval.

Unit	Description	No. of Lectures / Hours
I	Sequence and Series of Functions: Pointwise and Uniform Convergence, Cauchy Criterion for Uniform Convergence, Weierstrass M-Test, Abel's and Dirichlet's tests for Uniform Convergence	15
II	Function of Several Variables: Linear transformation, Derivatives in an open subset of $\mathbb{R}^n$, Contraction Principle, Inverse Function Theorem, Implicit Function, Derivatives of Higher Order, Differentiation of integrals	15
III	The Riemann–Stieltjes Integral: Definition and existence of Riemann–Stieltjes Integral Properties of the Integral, Integration and Differentiation, The Fundamental Theorem of Calculus, Integration of Vector-Valued Function	15
IV	Extremum problems with constraints: Lagrange's Multiplier Method, Differentiation of Integrals, Partitions of Unity, Differential Forms, Stokes' Theorem	15 15

Learning Resources

Reference Books

1. **Walter Rudin – *Principles of Mathematical Analysis* (3rd Edition), McGraw-Hill Kogakusha, 1976 (International Student Edition)**
2. **P.K. Jain and V.P. Gupta – *Lebesgue Measure and Integration*, New Age International Ltd., New Delhi, 1986 (Reprint)**
3. **T.M. Apostol – *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985**
4. **Gabriel Klambauer – *Mathematical Analysis*, Marcel Dekker, Inc., New York, 1975**
5. ***Real Analysis: An Introduction*, Addison-Wesley Publishing Co., Inc., 1968**
6. **E. Hewitt and K. Stromberg – *Real and Abstract Analysis*, Springer, Berlin, 1969**

E-Resources

- **NPTEL Online Courses**
- **e-PG Pathshala (INFLIBNET)**
- **SWAYAM**

SEMESTER I

PROGRAMME	**M.SC. MATHEMATICS – I SEMESTER**
CORE COURSE	**COURSE CODE: MMAT103**
TITLE	**TOPOLOGY - I**
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**
Course Learning Objective	The end of this course, the students will be able to: Gain knowledge of countable and uncountable sets, topological spaces, connectedness, compactness, first and second countable spaces, Projection maps, filters and their comparison. Gain skills to define topological spaces, product topology, metric topology, quotient space. Gain competency to discuss continuous functions, connected space, compact space, complete metric space, related theorem on Baire space. Gain competency of topological space and having grasp on basic result. Gain ability to express T-1, T-2, T-3 and T-4 separation axioms and use them to prove various properties.

Unit	Description	No. of Lectures / Hours
I	Definition and Examples of Metric Space; Definition and Examples of Topology; Neighbourhood; Countable and Uncountable Sets; Cantor's Theorem; Continuum Hypothesis	15
II	Definition and Examples of Topological Spaces; Closed Sets; Closure; Dense Subsets; Base and Sub-bases; Subspaces and Relative Topology; Continuity and Homomorphism	15
III	Connectedness; Continuity and Connectedness; Components; Totally Disconnected Space	15
IV	Compactness; Continuous Functions and Compact Sets; Sequentially and Countably Compact Sets; Compactness for Metric Spaces	15

Learning Resources

Reference Books

1. **Jame R. Munkres** – ***Topology: A First Course***
2. **K.D. Joshi** – ***Introduction to General Topology***
3. **J. Dugundji** – ***Topology***
4. **B. Mendelson** – ***Introduction to Topology***
5. **K.K. Jha** – ***Advanced General Topology***
6. **K.D. Joshi** – ***Introduction to General Topology*****, New Age International (P) Ltd., New Delhi**

E-Resources

- **NPTEL Online Courses**
- **e-PG Pathshala (INFLIBNET)**
- **SWAYAM**

SEMESTER I

PROGRAMME	**M.SC. MATHEMATICS – I SEMESTER**
CORE COURSE	**COURSE CODE: MMAT104**
TITLE	**COMPLEX ANALYSIS**
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**
Course Learning Objective	The end of this course, the students will be able to: Gain knowledge of complex integration, argument principle, Rouches theorem, Residues theorem, bilinear transformation, conformal mappings, Weierstrass factorization theorem, Runge's theorem, power series, canonical products, range of analytic function, Schottky's theorem, univalent function. Gain knowledge of expressing, Residue theorem and calculation of complex and real integrals. Gain ability of calculating complex integrals using Residue theorem. Gain ability to express logarithmic derivative and Rouche's theorem. Gain ability of viewing analytic functions as conformal mappings

Unit	Description	No. of Lectures / Hours
I	Algebra of Complex Numbers; The Complex Plane; Power Series; Analytic Functions of a Complex Variable; Limit of a Function; Continuity; Differentiability; Analytic and Regular Functions; Cauchy-Riemann Equations	15
II	Complex Integration; Cauchy–Goursat Theorem; Cauchy's Integral Formula; Higher Order Derivative; Morera's Theorem; Cauchy Inequality and Liouville's Theorem; The Fundamental Theorem of Algebra; Taylor's Theorem; Maximum Modulus Principle; Schwarz Lemma; Laurent's Series; Isolated Singularities	15
III	Residues; Cauchy's Residue Theorem; Evaluation of Integrals; Branches of Many-Valued Functions with Special References to $arg(z)$ and z^n; Bilinear Transformations – Their Conformal Mappings, Properties and Classification; Definitions and Examples of Mappings	15
IV	Spaces of Analytic Functions; Hurwitz's Theorem; Montel's Theorem; Riemann Mapping Theorem	15

Learning Resources

Reference Books

1. **B.S. Tyagi – *Functions of a Complex Variable*, Kedar Nath, Ram Nath Prakashan, Meerut, 1981**
2. **S. Ponnusamy – *Foundations of Complex Analysis*, Narosa Publishing House, 1997**
3. **L. Ahlfors – *Complex Analysis*, McGraw Hill Education**
4. **J.B. Conway – *Functions of One Complex Variable*, Springer-Verlag International Student Edition, Narosa Publishing House, 1990**
5. **S. Ponnusamy – *Foundations of Complex Analysis*, Narosa Publishing House, 1997 (Duplicate reference consolidated)**
6. **J.N. Sharma – *Functions of a Complex Variable***

E-Resources

- **NPTEL Online Courses**
- **e-PG Pathshala (INFLIBNET)**
- **SWAYAM**

SEMESTER I

PROGRAMME	**M.SC. MATHEMATICS – I SEMESTER**
CORE COURSE	**COURSE CODE: MMAT105**
TITLE	**ADVANCED DISCRETE MATHEMATICS - I**
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**
Course Learning Objective	The end of this course, the students will be able to: Gain knowledge of Mathematical logic, semi groups and monoids, lattices, Boolean Algebra, logical circuit, graph theory, trees, planar graphs, matrices of graphs, directed graphs, formal languages, grammars and finite state machine. Gainability to define semi groups, monoids homomorphism and isomorphism. Gainability to interpret lattices, Boolean Algebra, Karnaugh map, switching circuits. Gainability to use graphs as unifying theme for various combinatorial problems. Gainability to illustrate tautology, tautological implications, truth tables, normal forms, principal normal forms. Gainability to write an argument using logical notation and determine if the aruments is or is not valid.

Unit	Description	No. of Lectures / Hours
I	Boolean Algebra: Boolean Algebras; Duality; Sub-Algebra; Homomorphism and Isomorphism of Boolean Algebra; Boolean Algebras as Lattices; Boolean Function; Direct Products; Atoms and Minterms; Minterm Boolean Forms	15
II	Lattices: Lattices as Partially Ordered Sets and their Properties; Duality; Lattices as Algebraic Systems; Sublattices; Direct Products; Homomorphism and Isomorphism; Bounded Lattices; Complete, Complemented, Modular, and Distributive Lattices	15
III	Mathematical Logic: Statements; Symbolic Representation; Tautologies; Contradictions; Duality; Operations; Quantifiers; Arguments; Predicates and Validity of Propositions	15
IV	Semigroups and Monoids: Definition and Examples of Semigroups and Monoids; Homomorphism of Semigroups and Monoids; Congruence Relation and Quotient Semigroup; Sub-Semigroup; Sub-Monoids	15

Learning Resources

Reference Books

1. **J.P. Tremblay & R. Manohar – *Discrete Mathematical Structures with Applications to Computer Science*, McGraw Hill Book Co., 1997**
2. **Seymour Lipschutz – *Finite Mathematics* (International Edition, 1993), McGraw Hill Book Co., New York**
3. **N. Deo – *Graph Theory with Applications to Engineering and Computer Science*, Prentice Hall of India**
4. **S. Wiitala – *Discrete Mathematics: A Unified Approach*, McGraw Hill Book Co., New York**
5. **C.L. Liu – *Elements of Discrete Mathematics*, McGraw Hill Book Co.**
6. **M.K. Gupta – *Discrete Mathematics*, Krishna Prakashan Media**

(Duplicate entries removed and arranged for clarity)

E-Resources

- **NPTEL Online Courses**
- **e-PG Pathshala (INFLIBNET)**
- **SWAYAM**

SEMESTER -II

PROGRAMME	**M.SC. MATHEMATICS – II SEMESTER**	
CORE COURSE	**COURSE CODE: MMAT201**	
TITLE	**ADVANCED ABSTRACT ALGEBRA – II**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Learning Objective	Gain knowledge of **Field Theory**. Gain knowledge of **Galois Theory**. Test if a polynomial is **irreducible in finite fields (Galois fields)**. Understand **Smith Normal Form** and **Principal Ideal Domains (PID)** in detail. Understand **Finitely Generated Modules over PID**.	
Unit	**Description**	**No. of Lectures / Hours**
I	Linear Transformation: Algebra of Linear Transformation; Characteristic Roots; Matrices and Linear Transformation	15
II	Canonical Forms: Similarity of Linear Transformations; Invariant Subspaces; Reduction to Triangular Forms	15
III	Nilpotent Transformations: Index of Nilpotency; Invariants of a Nilpotent Transformation; The Primary Decomposition Theorem; Jordan Blocks and Jordan Forms	15
IV	Smith Normal Form over a Principal Ideal Domain and Rank; Fundamental Structure Theorem for Finitely Generated Abelian Groups; Rational Canonical Form	15

Learning Resources

Reference Books

1. **P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul – *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, Indian Edition, 1997**
2. **Luther & I.B.S. Passi – *Algebra Vol. I, II & III*, Narosa Publishing House, New Delhi**
3. **I.N. Herstein – *Topics in Algebra*, Wiley Eastern, New Delhi**
4. **S. Lang – *Algebra* (3rd Edition), Addison-Wesley, 1993**
5. **N. Jacobson – *Basic Algebra Vols. I & II*, Hindustan Publishing Company, 1980**

E-Resources

- **NPTEL Online Courses**
- **e-PG Pathshala (INFLIBNET)**
- **SWAYAM**

SEMESTER -II

PROGRAMME	**M.SC. MATHEMATICS – II SEMESTER**	
CORE COURSE	**COURSE CODE: MMAT202**	
TITLE	**REAL ANALYSIS - II**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Learning Objective	By the end of this course, students will be able to: 1. **Understand** the concepts of Measurable Sets, Measurable Functions, Lebesgue Integrals, Differentiation, and Integration in the context of Lebesgue Spaces. 2. **Develop skills** to establish the Measurability or Non-Measurability of Sets and Functions. 3. **Apply** the conditions under which the Fundamental Theorem of Calculus is valid within the framework of Lebesgue Integration. 4. **Interpret** Differentiation and Integration as inverse operations in the broader context of Lebesgue Theory.	
Unit	**Description**	**No. of Lectures / Hours**
I	Power Series; Uniqueness Theorem for Power Series; Abel's Theorem and Taylor's Theorem; Tauber's Theorem; Lebesgue Outer Measure; Regularity; Measurable Set; Measurable Functions	15
II	Borel and Lebesgue Measurability; Non-negative Functions; The General Integral; Integration of Series; Measure and Outer Measures; Extension of Measure	15
III	Uniqueness of Extension; Completion of a Measure; Measure Spaces; Integration with Respect to a Measure; Riemann and Lebesgue Integrals; The Four Derivatives; Lebesgue Differentiation Theorem; Differentiation and Integration; Functions of Bounded Variation; L^p-Spaces	15
IV	Convex Functions; Jensen's Inequality; Hölder and Minkowski Inequalities; Completeness of L^p-Spaces; Convergence in Measure	15

Learning Resource
Reference Books:

1. *Lebesgue Measure and Integration* – P. K. Jain and V. P. Gupta, New Age International (P) Limited Publication, New Delhi, 1986 (Reprint 2000).
2. *Real Analysis* – H. L. Royden, Macmillan Publishing Co. Inc., Fourth Edition, New York, 1962.
3. *Methods of Real Analysis* – R. R. Goldberg.
4. *Principles of Mathematical Analysis* – W. Rudin.
5. *The Elements of Real Analysis* (2nd Edition) – R. G. Bartle, J. Wiley & Sons, New York, London.

E-Resources:

- NPTEL Online Courses
- e-PG Pathshala

SEMESTER -II

PROGRAMME	**M.SC. MATHEMATICS – II SEMESTER**	
CORE COURSE	**COURSE CODE: MMAT203**	
TITLE	**TOPOLOGY - II**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Learning Objective	By the end of this course, the students will be able to: 1. Gain the ability to express regularity and normality separation axioms and use them to prove various properties. 2. Gain skills to construct the product topology on product spaces. 3. Prove basic results about completeness, connectedness, and convergence within these structures. 4. Learn about nets and convergence, filters, and ultrafilters.	
Unit	**Description**	**No. of Lectures / Hours**
I	First and second countable spaces, Lindelöf theorem, Separable spaces, Second Countability and Separability	15
II	Separation axioms: T_0, T_1, T_2, T_3, T_4 – their characterization and basic properties, Urysohn's Lemma, Tietze Extension Theorem	15
III	Projection Maps, Product invariant properties, Finite products, Tychonoff products, Tychonoff Theorem, Alexander Sub-base Lemma, Embedding and Metrization Theorem, Urysohn's Embedding Theorem	15
IV	Filters and their comparison, Ultrafilters, Filter bases, Convergence of filters, Characterization of continuity by filters, Convergence of nets, Hausdorffness and nets	15

Learning Resources

Reference Books:

1. G.F. Simmons – *Introduction to Topology and Modern Analysis*, McGraw-Hill.
2. M.J. Mansfield – *Introduction to Topology*, Van Nostrand, Princeton, New Jersey, 1963.
3. James R. Munkres – *Topology: A First Course*, Prentice Hall, 1974.
4. J. Dugundji – *Topology*, Boston: Allyn and Bacon, 1966.
5. B. Mendelson – *Introduction to Topology*, Dover Publications, 1990.
6. K.D. Joshi – *Introduction to General Topology*.
7. J.N. Sharma – *Topology*.
8. K.K. Jha – *Advanced General Topology*.

E-Resources:

- NPTEL Online Courses
- INFLIBNET e-PG Pathshala
- SWAYAM Portal

SEMESTER -II

PROGRAMME	**M.SC. MATHEMATICS – II SEMESTER**	
CORE COURSE	**COURSE CODE: MMAT204**	
TITLE	**COMPLEX ANALYSIS - II**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Learning Objective	By the end of this course, students will be able to: 1. Represent functions as Taylor, Power, and Laurent series, classify singularities and poles, find residues, and evaluate complex integrals using the residue theorem. 2. Apply problem-solving techniques using complex analysis in diverse contexts such as Physics, Engineering, and Mathematics. 3. Express entire functions in the form of canonical products, understand the theory related to the convergence of infinite products, and express some well-known functions as infinite products.	
Unit	**Description**	**No. of Lectures / Hours**
I	Power series method of analytic continuation, Schwartz Reflection Principle, Monodromy theorem and its consequences, Harmonic function on a disc, Harnack's inequality and theorem.	15
II	Weierstrass factorization theorem, Gamma function and its properties, Riemann Zeta function, Riemann's functional equation, Runge's theorem, Mittag-Leffler's theorem.	15
III	The range of an analytic function, Bloch's theorem, The Little Picard theorem, Schottky's theorem, Univalent functions, Bieberbach's conjecture and the "1/4-theorem".	15
IV	Entire functions: Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization theorem, The Gamma function.	15

Learning Resources

Reference Books:

1. **B. S. Tyagi:** ***Functions of a Complex Variable*****, Kedar Nath, Ram Nath Prakashan, Meerut, 1981.**
2. **S. Ponnusamy:** ***Foundation of Complex Analysis*****, Narosa Publishing House, 1997.**
3. **L. Ahlfors:** ***Complex Analysis*****, McGraw Hill Education.**
4. **J. B. Conway:** ***Functions of One Complex Variable*****, Springer-Verlag International Student Edition, Narosa Publishing House, 1980.**
5. **D. Sarason:** ***Complex Function Theory*****, Hindustan Book Agency, Delhi, 1994.**

E-Resources:

- **NPTEL Online Courses**
- **INFLIBNET e-PG Pathshala**
- **SWAYAM**

SEMESTER -II

PROGRAMME	**M.SC. MATHEMATICS – II SEMESTER**	
CORE COURSE	**COURSE CODE: MMAT205**	
TITLE	**ADVANCED DISCRETE MATHEMATICS – II**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Learning Objective	By the end of this course, the students will be able to: • Demonstrate traversal methods for trees and graphs. • Assimilate various graph theoretic concepts and familiarize with their applications. • Gain knowledge of languages and grammars, finite state machines and their transitions, machine minimization, and describe homomorphism automata and their equivalence to deterministic finite automata. • Understand counting methods, probability, and probability inequalities.	
Unit	**Description**	**No. of Lectures / Hours**
I	Formal Languages, Grammar and Finite State Machines; Grammars; Finite State Machines and their Transition Table Diagrams; Equivalence of Finite State Machines; Machine Minimization / Reduced Machines; Homomorphism in Finite Automata and their equivalence with Deterministic Finite Automata; Turing Machines and Partial Recursive Functions	15
II	Logical Circuits: Application of Boolean Algebra, Switching Theory (Using AND, OR, NOT gates), Finite state Machines and their Transition, Table diagrams, Equivalence of Finite state Machines, reduced machines, Homomorphism Finite automata, and equivalence of its power to that of Deterministic finite automata, Moore and Mealy Machines, Turing machines, and partial recursive functions.	15
III	Graph Theory: Graphs, Subgraphs and Complements; Walks, Paths, Circuits; Connected Graphs and Components; Operations on Graphs; Types of Graphs; Eulerian Graphs, Fleury's Algorithm, Hamiltonian Graphs; Weighted Undirected Graphs; Dijkstra's Algorithm; Strong Connectivity and Warshall's Algorithm	15
IV	Planar Graphs; Matrices of Graphs; Directed Graphs; Trees, Spanning Trees, Directed Trees, Search Trees, Tree Traversals; Fundamental Circuits; Planar Graphs; Euler's Formula for Connected Planar Graphs	15

Part C: Learning Resource

Reference Books

1. J.P. Tremblay & R. Manohar: *Discrete Mathematical Structure with Applications to Computer Science*. McGraw Hill Book Co., 1997.
2. Seymour Lipschutz: *Finite Mathematics* (International Edition, 1993). McGraw Hill Book Co., New York.
3. N. Deo: *Graph Theory with Applications to Engineering and Computer Science*. Prentice Hall of India.
4. S. Wiitala: *Discrete Mathematics – A Unified Approach*. McGraw Hill Book Co., New York.
5. C. L. Liu: *Elements of Discrete Mathematics*. McGraw Hill Book Co.

E-Resources

- NPTEL Online Courses
- e-PG Pathshala (INFLIBNET)
- SWAYAM

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**Course Code: MMAT301**	
TITLE	**Integration Theory and Functional Analysis -I (Compulsory)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of measure theory, signed measures, decomposition theorems, measure extensions, and advanced mathematical analysis concepts. • Provide knowledge of Lebesgue integration, product measures, convergence theorems, and integral operators for analytical problem solving. • Introduce Hausdorff measures, bounded variation, measure regularity, and representation theorems supporting functional analysis and mathematical research.	
Course Outcomes	**CO1:** Apply measure theory concepts, decomposition theorems, Radon–Nikodym theorem, and measure extensions to solve advanced mathematical problems. **CO2:** Evaluate Lebesgue–Stieltjes integrals, product measures, convergence theorems, and integral operators for advanced analytical applications successfully. **CO3:** Analyze Hausdorff measures, bounded variation, differentiation, integration, and measure decomposition within advanced mathematical analysis frameworks effectively. **CO4:** Demonstrate understanding of Baire measures, regular measures, compact support, and Riesz–Markov theorem in functional analysis applications.	
UNIT	**Description**	**No. of Lectures / Hours**
I	Signed measures, Jordan decomposition theorem, Hahn decomposition theorem, mutually singular measures, total variation of a signed measure, Radon–Nikodym theorem, Lebesgue decomposition theorem, Riesz representation theorem, Carathéodory Extension theorem.	**15**
II	Lebesgue–Stieltjes integral, product measures, Fubini's theorem, Tonelli's theorem, applications of Monotone Convergence Theorem and Dominated Convergence Theorem, integral operators, inner measure, Carathéodory outer measure.	**15**
III	Extension by sets of measure zero, Hausdorff measure, differentiation and integration, decomposition into absolutely continuous and singular parts, functions of bounded variation and their relation to the Lebesgue–Stieltjes integral.	**15**
IV	Extension by sets of measure zero, Hausdorff measure, differentiation and integration, decomposition into absolutely continuous and singular parts, functions of bounded variation and their relation to the Lebesgue–Stieltjes integral.	**15**

Text and Reference Books:

1. H.L. Royden: Real Analysis, Macmillan Publishing Co. Inc., New York, 4th Edition, 1993.
2. B.Choudhary and Sudarsan Nanda: Functional Analysis with Applications Wiley EasternLtd., 1989
3. J.H. Williamson: Lebesgue Integration, Holt Rinehart and Winston, Inc. New York. 1962
4. P.R. Halmos: Measure Theory, Van Nostrand, Princeton, 1950.
5. T.G. Hawkins: Lebesgue's Theory of Integration: Its Origins and Development, Chelsea, New York,1979.
6. B.V.Limaye: Functional Analysis, Wiley Eastern Ltd.
7. G.de. Barra: Measure Theory & Integration, Wiley Eastern Ltd, 1981.
8. Walter Rudin: Real & Complex Analysis, Tata McGraw Hill Publishing. Company, New Delhi.
9. P.K.Jain ,O.P.Ahuja& Khalid Ahmad: Functional Analysis, New Age International (P)Ltd., New Delhi.
10. A.Siddiqui: Functional Analysis with Applications: Tata McGraw Hill Publishing Company, New Delhi.

E -Resources:

1. **https://nptel.ac.in/courses/111104130?utm**
2. **https://nptel.ac.in/courses/111106131?utm**
3. **https://ocw.mit.edu/courses/18-125-measure-and-integration-fall-2003/?utm**
4. **https://courses.maths.ox.ac.uk/?utm**

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT302**	
TITLE	**Partial Differential Equations, Mechanics and Gravitation – I (COMPULSORY)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of partial differential equations, classical solution methods, and analytical techniques for solving mathematical physics problems effectively. • Provide knowledge of transform methods, conservation laws, boundary value problems, and applications in mathematical and physical sciences. • Introduce Newtonian gravitation, gravitational potential, Laplace and Poisson equations, and their applications in mathematical modeling studies.	
Course Outcomes	**CO1:** Solve Laplace, heat, and wave equations using fundamental solutions, energy methods, and boundary value techniques successfully. **CO2:** Apply first-order partial differential equation techniques, characteristics, Hamilton–Jacobi equation, and Cauchy problems to mathematical modeling. **CO3:** Analyze conservation laws, transform methods, Fourier series, and separation of variables for solving boundary value problems efficiently. **CO4:** Evaluate Newtonian attraction, gravitational potential, Laplace and Poisson equations, and Gauss theorem applications in gravitation problems accurately.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	**Laplace equation:** Fundamental solution, mean value formulae, properties of harmonic functions, maximum principle, uniqueness theorem, Green's function and energy method. **Heat equation:** Fundamental solution, mean value formulae, properties of solutions and energy method.	**15**
UNIT - II	**Wave equation:** Solutions by spherical means, homogeneous equations and energy method. **First-order partial differential equations:** Lagrange's linear equation, nonlinear first-order PDEs, complete integrals, envelopes, characteristics, Cauchy problem, Hamilton–Jacobi equation and its applications.	**15**
UNIT - III	Conservation laws, representation of solutions, separation of variables, Laplace transform, Fourier transform and their applications to boundary value problems, Fourier series (elementary applications), Legendre transform.	**15**
UNIT - IV	**Newtonian attraction:** Attraction of rod, disc, spherical shell, solid sphere and spherical shell of finite thickness. Gravitational potential and equipotential surfaces. Surface integral of normal attraction (applications of Gauss theorem), Laplace and Poisson equations, work done by a self-attracting system.	**15**

Text and Reference Books:

1. D.Raisinghania: Ordinary and Partial Differential Equation, S.Chand , New Delhi.
2. Gupta, Kumar & Sharma: Classical - Mechanics, Pragati Prakashan,
3. S.L. Loney :An Elementary Treatise On Statics,University Press.
4. I.N. Sneddon: Partial Differential Equation , McGraw Hill Book Co.Ltd.
5. H.Goldstem: Classical Mechanics, Addition Wesley.
6. Narayan Chandra Rana&PramodSharad, Chandra Joag: Classical Mechanics. Tata McGraw-Hill Publishing Company, 1991.
7. B.D. Gupta &SatyaPrakash: Mechanics Relativity .PragatiPrakshan, Meerut.

E -Resources:

1. https://nptel.ac.in/courses/111106152?utm
2. https://nptel.ac.in/courses/111104143?utm
3. https://ocw.mit.edu/courses/18-303-linear-partial-differential-equations-fall-2006/?utm
4. https://nptel.ac.in/courses/111106124?utm
5. https://nptel.ac.in/courses/115104094?utm
6. https://nptel.ac.in/courses/115101001?utm

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT303**	
TITLE	**Program. in C with ANSI Features I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop fundamental programming skills using C language, algorithms, flowcharts, and structured problem-solving techniques for computational applications effectively. • Provide comprehensive knowledge of C language syntax, data types, pointers, storage classes, and memory management concepts systematically. • Introduce control structures, operators, expressions, and debugging techniques for developing efficient, reliable, and maintainable C programs successfully.	
Course Outcomes	**CO1:** Design algorithms, flowcharts, and C programs using appropriate programming constructs for solving computational problems effectively and accurately. **CO2:** Apply C data types, pointers, storage classes, type conversions, and memory concepts in programming applications successfully and efficiently. **CO3:** Implement decision-making, looping, branching, and debugging techniques to develop structured, error-free, and efficient C programs confidently. **CO4:** Evaluate expressions, operators, precedence rules, and programming logic while identifying and correcting common programming errors effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	Introduction to programming, algorithms and flowcharts, programming languages and their classification, program development methodology, compilation, linking and execution process. C essentials, anatomy of a C program, variables and constants, expressions, assignment statements, formatting source files, continuation character and C preprocessor.	**15**
UNIT - II	Scalar data types, declaration of variables, integer and floating-point data types, integer constants, initialization, type conversion, explicit casting, enumeration types, void data type, typedef, storage classes (auto, register, static, extern), address operator and pointers.	**15**
UNIT - III	Control flow statements: conditional branching, switch statement, looping statements, nested loops, break, continue and goto statements, infinite loops. Structured programming concepts and elementary debugging techniques.	**15**
UNIT - IV	Operators and expressions: operator precedence and associativity, unary and binary operators, arithmetic and assignment operators, increment and decrement operators, comma operator, relational operators, logical operators, bitwise operators, bitwise assignment operators, cast operator, size of operator, conditional operator, memory operators, expression evaluation and common programming errors.	**15**

Text and Reference Books:

1. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 1993.
2. Brian W. Kernighan & Dennis M. Ritohie: The C Programme Language, 2nd Edition (ANSI Features), Prentice Hall 1989.
3. YashwantKanetkar: Let Us C, 8th Edison, B P B Publications 2007.
4. E. Balagurusamy: Programming in C (ANSI), 4th Edison, Tata Mac Graw Hill

E -Resources:

1. https://nptel.ac.in/courses/106105171?utm
2. https://nptel.ac.in/courses/106105171?utm
3. https://spoken-tutorial.org/tutorial-search/?search_foss=C+and+C%2B%2B&utm
4. https://swayam.gov.in?utm
5. https://cs50.harvard.edu/x/?utm

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT304**	
TITLE	**Fuzzy Sets and their Applications-I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of fuzzy sets, membership functions, operations, decomposition theorems, and fuzzy logic fundamentals for uncertainty modeling. • Provide knowledge of fuzzy numbers, arithmetic operations, fuzzy relations, and compositions for solving real-world mathematical problems effectively. • Introduce fuzzy relation equations, decision-making techniques, and engineering applications using fuzzy systems for intelligent problem-solving approaches.	
Course Outcomes	**CO1:** Apply fuzzy set concepts, membership functions, operations, complements, and decomposition theorems to model uncertain mathematical situations effectively. **CO2:** Perform arithmetic operations, ranking, and analysis of fuzzy numbers while solving elementary fuzzy equations accurately and efficiently. **CO3:** Analyze fuzzy relations, equivalence relations, compositions, and morphisms for modeling complex relationships in uncertain systems successfully. **CO4:** Solve fuzzy relation equations and apply fuzzy decision-making techniques to engineering, management, and real-world optimization problems effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	Introduction to crisp sets and fuzzy sets, basic definitions of fuzzy sets, membership functions and their graphical representation, α-cuts, convex fuzzy sets, basic operations on fuzzy sets, types of fuzzy sets, properties of α-cuts, representation of fuzzy sets, first and second decomposition theorems, extension principle for fuzzy sets, fuzzy complements, characterization theorems on fuzzy complements, t-norms and t-conorms, algebraic product and sum, bounded difference and bounded sum, characterization of t-norms and t-conorms, combination of operators.	**15**
UNIT - II	Fuzzy numbers, triangular and trapezoidal fuzzy numbers, arithmetic operations on fuzzy numbers, lattices of fuzzy numbers, ranking of fuzzy numbers (elementary methods), fuzzy equations.	**15**
UNIT - III	Fuzzy relations on fuzzy sets, fuzzy binary relations, fuzzy equivalence relations, compatibility relations (elementary), fuzzy morphisms, standard composition, max–min (sup–min) composition and min–max (inf–max) composition of fuzzy relations.	**15**
UNIT - IV	Fuzzy relation equations, problem partitioning, solution methods, fuzzy relation equations based on sup–min and inf–max compositions, approximate solutions, elementary concepts of fuzzy decision making and selected applications of fuzzy relation equations in engineering and management.	**15**

Text and Reference Books:

1. G.J. Klir and B. Yuan: Fuzzy Sets and Fuzzy logic, Prentice Hall of India New Delhi

2. H.J. Zimmermann: Fuzzy Sets and Fuzzy logic, Prentice Hall of India New Delhi
3. Dr. C. S Rathore: fuzzy sets and fuzzy logic Evincepub publishing.

E -Resources:

1. https://nptel.ac.in/courses/106105173?utm
2. **https://swayam.gov.in?utm**
3. **https://ocw.mit.edu?utm_source=**

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT305**	
TITLE	**Operations Research-I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of operations research techniques, linear programming models, optimization methods, and mathematical decision-making for practical applications. • Provide knowledge of advanced linear programming, transportation, assignment, and network optimization techniques for efficient resource allocation. • Introduce project planning, scheduling, and optimization methods using PERT, CPM, and time–cost trade-off analysis effectively.	
Course Outcomes	**CO1:** Formulate and solve linear programming problems using simplex, duality, sensitivity analysis, and advanced optimization techniques successfully. **CO2:** Analyze advanced linear programming models, interior point methods, and goal programming for effective decision-making and optimization. **CO3:** Solve assignment, transportation, and network optimization problems using standard algorithms for efficient resource management and planning. **CO4:** Apply PERT, CPM, critical path analysis, and project scheduling techniques to optimize project completion and resource utilization effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	Introduction to Operations Research, scope and applications, mathematical formulation of Operations Research models. **Linear Programming Problems (LPP):** graphical method of solution, simplex method, theory of simplex method, two-phase method, Big-M method, duality in linear programming, duality theorems, dual simplex method and introductory sensitivity (post-optimality) analysis.	**15**
UNIT - II	**Advanced Linear Programming:** Parametric Linear Programming, upper bound technique, interior point algorithm, linear goal programming, degeneracy, alternate optimal solutions, unbounded and infeasible solutions in linear programming.	**15**
UNIT - III	**Assignment Problems:** Mathematical formulation, Hungarian method, solution procedures and optimality test. **Transportation Problems:** Mathematical formulation, North-West Corner Method, Least Cost Method, Vogel's Approximation Method (VAM), optimality test using U–V (MODI) method.	**15**
UNIT - IV	**Network Analysis:** Shortest path problem, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex method. **Project Planning and Control:** PERT and CPM, critical path analysis, project scheduling and elementary time–cost trade-off (crashing).	**15**

Text and Reference Books:

1. F.S. Hillier and G.J. Ueberman: Introduction to Operations ResBareft (Sixth Edition), McGraw Hill International Edition, Industrial Engineering Series, 1995 Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.
2. G. Hadley: Linear Programming, Narosa Publishing House, 1995.
3. G. Hadly, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
4. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali: Linear Programming and Network flows, John Wiley I ' & Sons, New York, 1990.
5. H.A. Taha: Operations Researc~-An introduction, Macmillan Publishing Co., Inc., New Yark.
6. K. Swarup, P.K. Gupta and M. Mohan: Operations Research, Sultan Chand & Sons, N.Delhi.
7. S.S. Rao: Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
8. P. K..Gupla and D.S. Hira, : Operations Research ,S. Chand & Co. Ltd., New Delhi.
9. N.S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.
10. S.D.Sharma: Operations Research, KedarNath Ram Nath Publication, Meerut.

E -Resources:

1. https://nptel.ac.in/courses/110106062?utm_source=
2. https://nptel.ac.in/courses/111104071?utm_source=
3. https://nptel.ac.in/courses/110106140?utm_source=
4. https://nptel.ac.in/courses/110104073?utm_source=
5. https://ocw.mit.edu/courses/15-053-optimization-methods-in-management-science-spring-2013/?utm_source=

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT306**	
TITLE	**Fluid Mechanics-I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of fluid kinematics, flow descriptions, continuity equations, and rotational motion for analyzing fluid behavior effectively. • Provide knowledge of fluid dynamics, governing equations, energy principles, and circulation theorems for engineering and mathematical applications. • Introduce two-dimensional fluid motion, complex potential theory, conformal transformations, and cylinder flow analysis using classical fluid mechanics.	
Course Outcomes	**CO1:** Apply fluid kinematics concepts, continuity equation, velocity potential, and vorticity to analyze fluid flow characteristics accurately. **CO2:** Solve fluid motion problems using Euler equations, Bernoulli equation, energy principles, and circulation theorems effectively and systematically. **CO3:** Analyze two-dimensional fluid motion using stream functions, complex potentials, conformal transformations, and classical flow theorems successfully. **CO4:** Evaluate fluid flow around cylinders, circulation effects, lift forces, and Kutta–Joukowski theorem for practical engineering applications effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	**Fluid kinematics:** Lagrangian and Eulerian descriptions, equation of continuity, streamlines, pathlines, streaklines, stream tubes, velocity potential, rotational and irrotational motion, vorticity, circulation, boundary surfaces and vortex lines.	**15**
UNIT - II	**Equations of motion:** Euler's dynamical equations, Bernoulli's equation, equations of motion by flux method, equations of motion under impulsive forces, principle of energy for incompressible fluids, Lagrange's equations and Kelvin's circulation theorem (statement and applications).	**15**
UNIT - III	**Two-dimensional motion:** Lagrange's stream function, irrotational motion in two dimensions, complex velocity potential, uniform flow, sources, sinks, doublets and their images, superposition principle, conformal transformations, Milne–Thomson Circle Theorem and Blasius theorem.	**15**
UNIT - IV	**Motion of cylinders:** Motion of general, circular and coaxial cylinders, circulation about a moving cylinder, streaming and circulation about a fixed circular cylinder, lift force on a rotating cylinder and Kutta–Joukowski theorem (elementary treatment).	**15**

Text and Reference Books:

1. A.S.Ramsey: Atreatise on Hydrodynamics Part II, CBS Publication , Delhi
2. F.Choriton: Text book of Fluid Mechanics, CBS Publication , Delhi

3. L.D.Landan&E.M.Lipschitz : Fluid Mechanics , Pergaman Press.
4. R.K.Rathy: An Introduction to Fluid Dynamics, Oxford and IBH Company, New Delhi, 1976.

E -Resources:

1. **https://nptel.ac.in/courses/112105183?utm_source=**
2. **https://nptel.ac.in/courses/112106287?utm_source=**
3. **https://ocw.mit.edu/courses/2-25-advanced-fluid-mechanics-fall-2013/?utm_source=**
4. **https://www.maths.cam.ac.uk/undergrad/course/materials?utm_source=**

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT307**	
TITLE	**Information Theory-I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of information measures, entropy concepts, probability distributions, and uncertainty quantification in information theory applications effectively. • Provide knowledge of entropy properties, relative entropy, information functions, and axiomatic foundations for mathematical information analysis systematically. • Introduce coding theorems, mutual information, channel capacity, and fundamental concepts supporting modern communication and information systems effectively.	
Course Outcomes	**CO1:** Apply entropy measures, probability distributions, and uncertainty principles to analyze information content in mathematical communication systems accurately. **CO2:** Analyze entropy properties, relative entropy, and axiomatic characterizations for evaluating information and uncertainty in diverse applications effectively. **CO3:** Evaluate information functions, mutual information, and fundamental information equations for solving theoretical communication problems systematically and accurately. **CO4:** Demonstrate understanding of source coding theorem, channel capacity, and fundamental information theory principles for communication system analysis.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	**Measure of information:** Axioms for a measure of uncertainty, self-information, probability distributions, Shannon entropy and its properties, joint entropy, conditional entropy, transformations and their properties.	**15**
UNIT - II	**Properties of entropy:** Symmetry, normalization, expansibility, boundedness, recursivity, maximality, stability, additivity, subadditivity, non-negativity, continuity, branching and interrelations among these properties. Relative entropy (Kullback–Leibler divergence) – elementary concepts. Axiomatic characterization of Shannon entropy due to Tverberg and Leo.	**15**
UNIT - III	**Two-dimensional motion:** Lagrange's stream function, irrotational motion in two dimensions, complex velocity potential, uniform flow, sources, sinks, doublets and their images, superposition principle, conformal transformations, Milne–Thomson Circle Theorem and Blasius theorem.	**15**
UNIT - IV	Fundamental theorem of Information Theory and its weak and strong converses. Source coding theorem (statement and significance), introductory concept of channel capacity.	**15**

Text and Reference Books:

1. R.ASH: Information Theory, Inter science Publishers, New York, 1965.
2. F.M. REZA: An Introduction to Information Theory, McGraw Hill Book Company, Inc.,1961
3. J,Aczel and Z.Daroczy: On Measures of Information and their characterization, Academic Press, New York.

E -Resources:

1. https://nptel.ac.in/courses/117101053?utm_source=
2. https://nptel.ac.in/courses/117102059?utm_source=
3. https://ocw.mit.edu/courses/6-441-information-theory-spring-2016/?utm_source=
4. https://web.stanford.edu/class/ee376a/?utm_source=

SEMESTER -III

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT308**	
TITLE	**Fundamentals of Computer Science –I (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of object-oriented programming concepts, classes, inheritance, polymorphism, and templates for efficient software development practices effectively. • Provide knowledge of algorithm analysis, recursion, and fundamental data structures for solving computational problems efficiently and systematically. • Introduce trees, hashing, sorting algorithms, and complexity analysis for designing optimized and scalable computer science applications effectively.	
Course Outcomes	**CO1:** Apply object-oriented programming principles, classes, inheritance, polymorphism, and templates to develop efficient C++ software applications successfully. **CO2:** Analyze algorithms using asymptotic notations, recursion, and complexity measures for efficient computational problem-solving and performance evaluation effectively. **CO3:** Implement lists, stacks, queues, and tree data structures for solving practical computer science and programming problems efficiently. **CO4:** Evaluate hashing techniques, sorting algorithms, and time complexity to optimize data organization and software performance effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
UNIT - I	Introduction to Object-Oriented Programming, principles of OOP (encapsulation, abstraction, inheritance and polymorphism), classes and scope, nested classes, pointers, class members, constructors, destructors, class initialization, assignment and destruction.	**15**
UNIT - II	Function overloading, operator overloading, templates and class templates, class inheritance and subtyping, multiple and virtual inheritance, virtual functions and runtime polymorphism.	**15**
UNIT - III	Analysis of algorithms, asymptotic notations (Big O, Big Ω and Big Θ), recursion and recursive algorithms. Data structures: lists, stacks and queues, sequential and linked representations, applications of stacks and queues.	**15**
UNIT - IV	Trees: Binary trees, binary search trees and tree traversals, B-tree (concept only). Hashing: open and closed hashing. Sorting: insertion sort, shell sort, quick sort and heap sort, comparison of sorting algorithms and time complexity analysis.	**15**

Text and Reference Books:

1. S.B.Lipman, J.Lajoi: C++ Primer, Addition Wesey.
2. B.Stroustrup: The C++ Programming Language, Addition Wesey.
3. C.J.Date: Introduction to Database System, Addition Wesley.

E -Resources:

1. **https://nptel.ac.in/courses/106105151?utm_source=**
2. **https://nptel.ac.in/courses/106105224?utm_source=**
3. **https://nptel.ac.in/courses/106102064?utm_source=**
4. **https://nptel.ac.in/courses/106101060?utm_source=**
5. **https://nptel.ac.in/courses/106101060?utm_source=**
6. **https://online.stanford.edu/courses/soe-ycsalgorithms-algorithms-design-and-analysis?utm_source=**

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT401**	
TITLE	**Integration Theory and Functional Analysis – II (Compulsory)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of normed linear spaces, Banach spaces, bounded operators, and dual spaces in functional analysis comprehensively. • Provide knowledge of fundamental functional analysis theorems, compact operators, weak convergence, and solvability of linear equations effectively. • Introduce Hilbert spaces, orthogonality, operator theory, and spectral concepts for advanced mathematical analysis and research applications effectively.	
Course Outcomes	**CO1:** Apply concepts of normed linear spaces, Banach spaces, dual spaces, and bounded linear operators in mathematical analysis effectively. **CO2:** Analyze Hahn–Banach, Open Mapping, Closed Graph, and Uniform Boundedness theorems for solving functional analysis problems successfully. **CO3:** Construct orthonormal bases using Gram–Schmidt process and apply Hilbert space concepts to mathematical problems accurately and effectively. **CO4:** Evaluate bounded linear operators, adjoint operators, spectral properties, and Riesz Representation Theorem in Hilbert spaces systematically.	
UNIT	**Description**	**No. of Lectures / Hours**
I	Normed linear spaces, Banach spaces and examples, quotient spaces of normed linear spaces and their completeness, equivalent norms, Riesz lemma, finite-dimensional normed linear spaces and compactness, weak convergence, linear functionals, bounded and continuous linear transformations, normed linear spaces of bounded transformations and dual spaces with examples.	**15**
II	Uniform Boundedness Principle (Banach–Steinhaus theorem) and its consequences, Open Mapping Theorem, Closed Graph Theorem, Hahn–Banach Theorem for real, complex and normed linear spaces, reflexive spaces, weak and weak-* convergence (elementary concepts), weak sequential compactness, compact operators, solvability of linear equations in Banach spaces (Fredholm Alternative), Closed Range Theorem.	**15**
III	Inner product spaces, Hilbert spaces, Gram–Schmidt orthogonalization process, orthonormal sets, Bessel's inequality, complete orthonormal sets, Parseval's identity, structure of Hilbert spaces and Projection Theorem.	**15**
IV	Riesz Representation Theorem, adjoint of an operator on a Hilbert space, reflexivity of Hilbert spaces, self-adjoint, positive, projection, normal and unitary operators, elementary concepts of the spectrum of bounded linear operators.	**15**

Text and Reference Books:

1. H.L. Royden: Real Analysis, Macmillan Publishing Co. Inc., New York, 4th Edition, 1993.

2. B.Choudhary and Sudarsan Nanda: Functional Analysis with Applications Wiley EasternLtd., 1989
3. J.H. Williamson: Lebesgue Integration, Holt Rinehart and Winston, Inc. New York. 1962
4. P.R. Halmos: Measure Theory, Van Nostrand, Princeton, 1950.
5. T.G. Hawkins: Lebesgue's Theory of Integration: Its Origins and Development, Chelsea, New York, 1979.
6. B.V.Limaye: Functional Analysis, Wiley Eastern Ltd.
7. G.de. Barra: Measure Theory & Integration, Wiley Eastern Ltd, 1981.
8. Walter Rudin: Real & Complex Analysis, Tata McGraw Hill Publishing. Company, New Delhi.
9. P.K.Jain ,O.P.Ahuja& Khalid Ahmad: Functional Analysis, New Age International (P)Ltd., New Delhi.
10. A.Siddiqui: Functional Analysis with Applications: Tata McGraw Hill Publishing Company, New Delhi.

E -Resources:

1. https://nptel.ac.in/courses/111106131?utm_source=
2. https://nptel.ac.in/courses/111104125?utm_source=
3. https://ocw.mit.edu/courses/18-102-introduction-to-functional-analysis-spring-2021/?utm_source=
4. https://courses.maths.ox.ac.uk/?utm_source=

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT402**	
TITLE	**Partial Differential Equations, Mechanics & Gravitation – II (Compulsory)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of analytical mechanics, generalized coordinates, Lagrangian formulation, and Hamiltonian methods for dynamical system analysis effectively. • Provide knowledge of calculus of variations, optimization principles, and constrained extremum problems in mathematical and physical applications. • Introduce gravitational potential theory, harmonic functions, multipole expansion, and mass distribution analysis for advanced mechanics studies effectively.	
Course Outcomes	**CO1:** Apply Lagrangian and Hamiltonian formulations to analyze constrained mechanical systems and solve advanced dynamics problems systematically and accurately. **CO2:** Analyze Poisson brackets, canonical equations, and coordinate transformations for solving problems in classical analytical mechanics effectively and rigorously. **CO3:** Solve variational problems using Euler equations and optimization principles under geometric and integral constraints successfully and efficiently. **CO4:** Evaluate gravitational potentials, harmonic functions, multipole expansions, and mass distributions in advanced gravitation and mechanics applications effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
I	Generalized coordinates, holonomic and non-holonomic systems, scleronomic and rheonomic systems, generalized potentials, generalized momentum, principle of virtual work, D'Alembert's principle, Lagrange's equations of first and second kind, uniqueness of solution, energy equation for conservative fields.	**15**
II	Hamiltonian variables, Hamilton's canonical equations, cyclic coordinates, Routh's equations, Poisson brackets, Poisson identity, Jacobi–Poisson theorem, Lagrange brackets, elementary concepts of canonical transformations.	**15**
III	Calculus of variations: motivating problems, shortest distance, minimum surface of revolution, brachistochrone problem, isoperimetric problem, geodesics, fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalizations to several dependent variables and higher-order derivatives, transversality condition (elementary), Legendre necessary condition (introductory), conditional extrema under geometric and integral constraints.	**15**
IV	Gravitational potential of rod, disc, spherical shell, solid sphere and spherical shell of finite thickness, determination of mass distributions for a given potential, equipotential surfaces, surface harmonics, solid harmonics, surface density in terms of surface harmonics, elementary multipole expansion.	**15**

Text and Reference Books:

1. Gupta ,Kumar & Sharma: Classical - Mechanics, PragatiPrakashan,

2. S.L. Loney :An Elementary Treatise On Statics,University Press.
3. I.N. Sneddon: Partial Differential Equation , McGraw Hill Book Co.Ltd.
4. H.Goldstem: Classical Mechanics, Addition Wesley.
5. Narayan Chandra Rana&PramodSharad, Chandra Joag: Classical Mechanics. Tata McGraw-Hill Publishing Company, 1991.
6. B.D. Gupta &SatyaPrakash: Mechanics Relativity .PragatiPrakshan, Meerut.

E -Resources:

1. https://nptel.ac.in/courses/115104094?utm_source=
2. https://nptel.ac.in/courses/115106123?utm_source=
3. https://nptel.ac.in/courses/111108098?utm_source=
4. **https://ocw.mit.edu/courses/8-09-classical-mechanics-iii-fall-2014/?utm_source=**
5. **https://nptel.ac.in/courses/115101001?utm_source=**

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT403**	
TITLE	**Programming In C (With Ansi Features) – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of arrays, pointers, storage classes, and functions for efficient memory management and structured programming applications. • Provide knowledge of structures, unions, dynamic memory allocation, linked lists, and advanced C programming techniques systematically. • Introduce file handling, input-output operations, preprocessing directives, and standard libraries for developing robust C programming applications effectively.	
Course Outcomes	**CO1:** Implement arrays, pointers, functions, and storage classes to develop efficient and structured C programs for practical applications. **CO2:** Apply pointer arithmetic, recursion, multidimensional arrays, and preprocessing directives for solving advanced programming problems effectively and accurately. **CO3:** Design programs using structures, unions, linked lists, and dynamic memory allocation for efficient data organization and processing. **CO4:** Develop file handling applications using input-output streams, buffering, and standard libraries for reliable data management and processing.	
UNIT	**Description**	**No. of Lectures / Hours**
I	**Arrays:** Declaration, memory representation, initialization, character arrays, string handling, encryption and decryption techniques. **Storage classes:** automatic and static storage duration, scope, global variables, register specifier, extern storage class, ANSI syntax and semantics of storage-class keywords.	**15**
II	**Pointers:** Pointer arithmetic, pointers as function arguments, arrays and pointers, multidimensional arrays, arrays of pointers, pointers to pointers, const pointers, sorting algorithms using pointers. **Functions:** parameter passing, declarations and calls, pointers to functions, recursion, main() function with command-line arguments, complex declarations. **C preprocessor:** macro substitution, conditional compilation, include facility and line control.	**15**
III	**Structures and unions:** Structures, self-referential structures, unions, enumeration (enum) declarations, dynamic memory allocation (malloc, calloc, realloc, free), linked lists, stack and queue implementation using linked lists.	**15**
IV	**Input and output:** Streams, buffering, <stdio.h> header file, error handling, file opening and closing, reading and writing data, text and binary files, random access files, command-line file processing (elementary), standard input/output library.	**15**

Text and Refcrence Books:

1. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach, Narosa Publishing House

(Springer International Student Edition) 1993.

2. Brian W. Kernighan & Dennis M. Ritohie: The C Programme Language, 2nd Edition (ANSI Features), Prentice Hall 1989.
3. YashwantKanetkar: Let Us C, 8th Edison, B P B Publications 2007.
4. E. Balagurusamy: Programming in C (ANSI), 4th Edison, Tata Mac Graw Hill.

E -Resources:

1. https://nptel.ac.in/courses/106105171?utm_source=
2. **https://nptel.ac.in/courses/106105171?utm_source=**
3. **https://spoken-tutorial.org/tutorial-search/?search_foss=C+and+C%2B%2B&utm_source=**
4. **https://cs50.harvard.edu/x/?utm_source=**
5. **https://ocw.mit.edu/courses/6-0001-introduction-to-computer-science-and-programming-in-python-fall-2016/?utm_source=**

Practical

The break-up of marks for third Semester's Practical will be as under:			
Sr. No.	Argument	Maximum Marks	**Minimum Passing Marks**
1.	Lab Record (Internal Assessment)	**6**	
2.	Viva-voce (External Assessment)	**9**	
3.	Program Development and Execution (External Assessment)	**15**	
Total Marks		**30**	**11**

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT404**	
TITLE	**Fuzzy Sets and Their Applications – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of fuzzy measures, possibility theory, evidence theory, and uncertainty modeling for intelligent decision-making applications effectively. • Provide knowledge of fuzzy logic, inference systems, approximate reasoning, and fuzzy controllers for solving complex real-world problems. • Introduce fuzzy decision-making, optimization techniques, and engineering applications using fuzzy systems for advanced computational intelligence studies effectively.	
Course Outcomes	**CO1:** Apply fuzzy measures, possibility theory, and evidence theory to model uncertainty in practical decision-making problems effectively and accurately. **CO2:** Analyze fuzzy logic, inference models, linguistic variables, and approximate reasoning for intelligent system design successfully and systematically. **CO3:** Design fuzzy expert systems using fuzzification, inference engines, rule bases, and defuzzification methods for practical applications effectively. **CO4:** Evaluate fuzzy decision-making, optimization methods, and engineering applications using fuzzy linear programming and multi-criteria analysis techniques effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
I	Fuzzy measures, evidence theory, possibility theory, possibility distributions, necessity measures, comparison of possibility theory and probability theory.	**15**
II	Overview of classical logic, multivalued logics, fuzzy propositions, fuzzy quantifiers, linguistic hedges, inference from conditional and qualified fuzzy propositions, compositional rule of inference, Mamdani and Sugeno fuzzy inference models (elementary concepts).	**15**
III	Approximate reasoning, overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equations, knowledge base representation, fuzzy controllers, fuzzy rule base, fuzzy inference engine, fuzzification, membership function design (elementary), defuzzification and defuzzification methods: centre of area, centre of maxima and mean of maxima.	**15**
IV	Decision making in fuzzy environments: individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods, fuzzy linear programming, introductory fuzzy optimization and applications of fuzzy decision making in engineering and management.	**15**

Text and Reference Books:

1. G.J. Klir and B. Yuan: Fuzzy Sets and Fuzzy logic, Prentice Hall of India New Delhi
2. H.J. Zimmermann: Fuzzy Sets and Fuzzy logic, Prentice Hall of India New Delhi

3.

E -Resources:

1. **https://nptel.ac.in/courses/106105173?utm_source=**
2. **https://nptel.ac.in/courses/106105152?utm_source=**
3. **https://swayam.gov.in?utm_source=**
4. **https://ocw.mit.edu?utm_source=**

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**COURSE CODE: MMAT405**	
TITLE	**Operations Research – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of dynamic programming, game theory, and integer programming for solving optimization and decision-making problems effectively. • Provide knowledge of queueing theory, inventory control models, and performance analysis for efficient resource management applications systematically. • Introduce nonlinear programming, constrained optimization techniques, and mathematical models for solving complex operational research problems effectively.	
Course Outcomes	**CO1:** Apply dynamic programming, game theory, and integer programming techniques to solve optimization and strategic decision-making problems effectively. **CO2:** Analyze queueing systems and inventory models to evaluate performance measures and optimize resource allocation efficiently and accurately. **CO3:** Formulate and solve nonlinear optimization problems using Lagrange multipliers, Kuhn–Tucker conditions, and quadratic programming techniques successfully. **CO4:** Evaluate optimization models using gradient methods, separable programming, and convex programming for practical operations research applications effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
I	**Dynamic Programming:** Principle of optimality, deterministic and probabilistic dynamic programming. **Game Theory:** Two-person zero-sum games, saddle point, games with mixed strategies, graphical solution and solution using linear programming.	15
II	**Integer Programming:** Integer programming models, branch and bound technique, Gomory cutting plane method (introductory), binary integer programming (elementary concepts).	15
III	**Queueing Theory:** Deterministic queueing systems, probability distributions in queueing, classification of queueing models, Poisson queueing systems: (M/M/1):(∞/FIFO), (M/M/1):(∞/SIRO), (M/M/1):(N/FIFO), performance measures of queueing systems. **Inventory Control:** Economic Order Quantity (EOQ), deterministic inventory models with and without shortages.	15
IV	**Nonlinear Programming:** One-variable and multivariable unconstrained optimization, Lagrange multiplier method, Kuhn–Tucker conditions for constrained optimization, quadratic programming, separable programming, convex programming, non-convex programming and elementary gradient method.	15

Text and Reference Books:

1. 1. F.S. Hillier and G.J. Ueberman: Introduction to Operations ResBareft (Sixth Edition), McGraw Hill International Edition, Industrial Engineering Series, 1995 Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.

2. G. Hadley: Linear Programming, Narosa Publishing House, 1995.
3. G. Hadly, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
4. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali: Linear Programming and Network flows, John Wiley I ' & Sons, New York, 1990.
5. H.A. Taha: Operations Researc~-An introduction, Macmillan Publishing Co., Inc., New Yark.
6. K. Swarup, P.K. Gupta and M. Mohan: Operations Research, Sultan Chand & Sons, N.Delhi.
7. S.S. Rao: Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
8. P. K..Gupla and D.S. Hira, : Operations Research ,S. Chand & Co. Ltd., N.Delhi.
9. N.S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.
10. S.D.Sharma: Operations Research, KedarNath Ram Nath Publication, Meerut.

E -Resources:

1. https://nptel.ac.in/courses/110107081?utm_source=
2. https://nptel.ac.in/courses/110106062?utm_source=
3. https://nptel.ac.in/courses/111108128?utm_source=
4. https://ocw.mit.edu/courses/15-093j-optimization-methods-fall-2009/?utm_source=
5. https://web.stanford.edu/class/ee364a/?utm_source=

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**Course Code: MMAT406**	
TITLE	**Fluid Mechanics – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of advanced fluid motion, cylinder flow, vortex dynamics, and hydrodynamic forces for engineering applications effectively. • Provide knowledge of three-dimensional fluid motion, sphere dynamics, Stokes' law, and viscous flow behavior systematically and accurately. • Introduce vortex motion, wave propagation, and fluid dynamics principles for analyzing complex fluid flow phenomena effectively.	
Course Outcomes	**CO1:** Apply principles of elliptic cylinder motion, circulation, and hydrodynamic forces to solve advanced fluid mechanics problems effectively. **CO2:** Analyze three-dimensional fluid motion, sphere dynamics, Stokes' law, and terminal velocity in practical engineering applications accurately. **CO3:** Evaluate vortex motion, circulation theorems, vortex filaments, and Kármán vortex street for fluid flow analysis systematically and effectively. **CO4:** Analyze wave motion, progressive waves, standing waves, dispersion relations, and particle paths in ideal fluid dynamics successfully.	
UNIT	**Description**	**No. of Lectures / Hours**
I	**Motion of elliptic cylinders:** Streaming past a fixed elliptic cylinder, rotating elliptic cylinder, kinetic energy, circulation, lift force on an elliptic cylinder (elementary), hydrodynamic force and moment.	**15**
II	**Three-dimensional motion:** Motion of a sphere in a liquid at rest at infinity, liquid streaming past a fixed sphere, concentric spheres, equation of motion of a sphere, Stoke's stream function, Stokes' law and terminal velocity of a sphere.	**15**
III	**Vortex motion:** Vortex motion and its elementary properties, Kelvin's circulation theorem, Helmholtz vortex theorems (elementary), conservation of circulation, strength of a vortex tube, rectilinear vortices with circular and elliptic sections, pressure distribution, Rankine combined vortex, vortex pair, vortex filament, image of a vortex filament in a plane, Kármán vortex street.	**15**
IV	**Wave motion of an ideal fluid:** Wave motion and its properties, progressive waves on the surface of a canal and deep canal, standing waves, energy of progressive waves, reduction of progressive waves to steady motion, capillary waves, long gravity waves, phase velocity, group velocity, elementary wave dispersion relation and particle paths.	**15**

Text and Reference Books:

1. 1. A.S.Ramsey: Atreatise on Hydrodynamics Part II, CBS Publication , Delhi
2. F.Choriton: Text book of Fluid Mechanics, CBS Publication , Delhi
3. L.D.Landan&E.M.Lipschitz : Fluid Mechanics , Pergaman Press.

4. R.K.Rathy: An Introduction to Fluid Dynamics, Oxford and IBH Company, New Delhi, 1976.

E -Resources:

1. https://nptel.ac.in/courses/112105183?utm_source=
2. https://nptel.ac.in/courses/112106287?utm_source=
3. https://ocw.mit.edu/courses/2-25-advanced-fluid-mechanics-fall-2013/?utm_source=
4. https://www.maths.cam.ac.uk/undergrad/course/materials?utm_source=

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**Course Code: MMAT407**	
TITLE	**Information Theory – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of advanced fluid motion, cylinder flow, vortex dynamics, and hydrodynamic forces for engineering applications effectively. • Provide knowledge of three-dimensional fluid motion, sphere dynamics, Stokes' law, and viscous flow behavior systematically and accurately. • Introduce vortex motion, wave propagation, and fluid dynamics principles for analyzing complex fluid flow phenomena effectively.	
Course Outcomes	**CO1:** Apply principles of elliptic cylinder motion, circulation, and hydrodynamic forces to solve advanced fluid mechanics problems effectively. **CO2:** Analyze three-dimensional fluid motion, sphere dynamics, Stokes' law, and terminal velocity in practical engineering applications accurately. **CO3:** Evaluate vortex motion, circulation theorems, vortex filaments, and Kármán vortex street for fluid flow analysis systematically and effectively. **CO4:** Analyze wave motion, progressive waves, standing waves, dispersion relations, and particle paths in ideal fluid dynamics successfully.	
UNIT	**Description**	**No. of Lectures / Hours**
I	**Information functions:** General solution of the fundamental equation of information, derivations and their role in the study of information functions, functional equations associated with entropy, introductory generalized entropy measures.	**15**
II	**Continuous channels:** Time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, differential entropy, mutual information for continuous channels, converse to the coding theorem for the time-discrete Gaussian channel, band-limited channels.	**15**
III	**Noiseless coding:** Ingredients of the noiseless coding problem, uniquely decipherable codes, instantaneous (prefix) codes, Kraft–McMillan inequality, necessary and sufficient conditions for the existence of instantaneous codes, Huffman coding algorithm and construction of optimal codes.	**15**
IV	**Discrete memoryless channels:** Classification of channels, Binary Symmetric Channel (BSC), Binary Erasure Channel (BEC), information processed by a channel, calculation of channel capacity, Shannon Channel Coding Theorem (statement), decoding schemes and the ideal observer.	**15**

Text and Reference Books:

1. R.ASH: Information Theory , Inter science Publishers, New York, 1965.
2. F.M.REZA: An Introduction to Information Theory, McGraw Hill Book Company, Inc.,1961
3. J,Aczel and Z.Daroczy: On Measures of Information and their characterization, Academic Press, New York

E -Resources:

1. https://nptel.ac.in/courses/117101053?utm_source=
2. https://nptel.ac.in/courses/117102059?utm_source=
3. https://ocw.mit.edu/courses/6-441-information-theory-spring-2016/?utm_source=
4. https://web.stanford.edu/class/ee376a/?utm_source=

SEMESTER -IV

PROGRAMME	**M.SC. Mathematics**	
CORE COURSE	**Course Code: MMAT408**	
TITLE	**Fundamentals of Computer Science – II (Optional)**	
Total Marks	**Internal Assessment: 30 Marks Maximum Marks: 70 Minimum Passing Marks: 40**	
Course Objective	• Develop understanding of database management systems, data models, relational databases, and database design principles for efficient information management. • Provide knowledge of SQL, normalization, transactions, and database integrity for developing reliable and secure database applications effectively. • Introduce operating system concepts, process management, memory management, scheduling, and security for efficient computer system operations effectively.	
Course Outcomes	**CO1:** Apply database concepts, relational models, and ER diagrams to design efficient and well-structured database systems successfully. **CO2:** Implement SQL queries, normalization techniques, integrity constraints, and transactions for secure and reliable database management effectively. **CO3:** Analyze operating system functions, process scheduling, memory management, and input-output operations for efficient resource utilization systematically. **CO4:** Evaluate concurrency, deadlocks, virtual memory, file systems, and distributed operating systems for modern computing applications effectively.	
UNIT	**Description**	**No. of Lectures / Hours**
I	**Database Management Systems:** Role of DBMS, DBMS versus file system, database system architecture, data models (hierarchical, network and relational), Entity–Relationship (ER) model, introduction to relational algebra and relational calculus.	**15**
II	**Structured Query Language (SQL):** Basic features, Data Definition Language (DDL), Data Manipulation Language (DML), views, integrity constraints, keys (primary, foreign and candidate), database design, normalization up to Boyce–Codd Normal Form (BCNF), introduction to transactions and ACID properties.	**15**
III	**Operating Systems:** Functions of an operating system, user interface, process and thread concepts, processor management, CPU scheduling algorithms (FCFS, SJF and Round Robin), input/output management and memory management.	**15**
IV	**Operating Systems (Advanced Concepts):** Concurrency, deadlocks (introductory concepts), security, file systems, virtual memory, paging and segmentation (elementary concepts), network operating systems and distributed operating systems.	**15**

Text and Reference Books:

1. S.B. Lipman, J.Lajoi: C++ Primer, Addition Wesey.
2. B.Stroustrup: The C++ Programming Language, Addition Wesey.
3. C.J.Date: Introduction to Database System, Addition Wesley.

E -Resources:

1. https://nptel.ac.in/courses/106105175?utm_source=
2. https://nptel.ac.in/courses/106106093?utm_source=
3. https://nptel.ac.in/courses/106105214?utm_source=
4. https://nptel.ac.in/courses/106106144?utm_source=
5. https://ocw.mit.edu/courses/6-828-operating-system-engineering-fall-2012/?utm_source=