M.Sc. Mathematics

Course objectives and leaning outcomes

Semester: I-IV

Semester-I

Paper 1: MAT CC01 (Abstract Algebra)

Course Objectives: Group and Field theory forms one of the important and fundamental algebraic structures and has an extensive theory dealing mainly with field extensions which arise in the study of roots of polynomials. In this course we study Groups, fields and their properties in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Course Learning Outcomes: After studying this course the student will be able to

- Identify and construct examples of fields, distinguish between algebraic and transcendental extensions, characterize normal extensions in terms of splitting fields and prove the existence of algebraic closure of a field.
- Characterize perfect fields using separable extensions, construct examples of automorphism group of a field and Galois extensions as well as prove Artin's theorem and the fundamental theorem of Galois theory.
- Classify finite fields using roots of unity and Galois theory and prove that every finite separable extension is simple.
- Use Galois theory of equations to prove that a polynomial equation over a field of characteristic is solvable by radicals if its group (Galois) is a solvable group and hence deduce that a general quintic equation is not solvable by radicals.

Paper 2: MAT CC02 (Real Analysis)

Course Objectives: This course is designed to provide fundamental concept of analysis including classical theory of functions of real variable, differentiation and integration of real functions as well as fundamental topics like functions of several variables and Taylor theorem.

Course Learning Outcomes: After studying this course the student will be able to

- Define Riemann Stieltjes integral and illustrate the properties of integration and differentiation.
- Acquire the knowledge of sequence, series and uniformly convergence of series by different Test.
- To understand the statement and prove of important theorems.
- Apply the Taylors, Inverse function and Implicit function theorems to solve the problems.
- Apply the differentiation to find out the maximum and minimum value of a functions.

Paper 3: MAT CC-03 (Linear Algebra)

Course Objectives: This course to learn, how Linear Algebra is ubiquitous in Mathematics and therefore a strong foundation has to be laid in studying the abstract algebraic concepts intertwining geometric ideas. The fundamental notions of vector spaces viz linear dependence, basis and dimension and linear transformations on these spaces have to be studied thoroughly.

Course Learning Outcomes: After studying this course the student will be able to

- Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
- Relate matrices and linear transformation, compute Eigen values and Eigen vectors of linear transformations.
- Learn properties of inner product spaces and determine orthogonality in inner product spaces.
- Obtain various variants of diagonalisation of linear transformations.
- Realise importance of adjoint of a linear transformation and its canonical form.
- Solve Bilinear form, Quadratic form and Hermitian form.

Paper 4: MAT CC04 (Discrete Mathematics)

Course Objective: The objective of the course is to introduce students with the fundamental concepts in partially ordered sets, lattices, Boolean algebra and graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.

Course Learning Outcomes: After studying this course the student will be able to

- Understand the concepts of partially ordered sets, lattices and Hasse diagram.
- Learn the basic concepts of Boolean algebra, lattice, logical gates and relations of Boolean function along with Mathematical Logic: Statement and notations, proposition
- Analyze the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices and understand Eulerian and Hamiltonian graphs.
- Learn the use of the Pigeon hole principle.

Semester-II

Paper 5: MAT CC05 (General Advanced Mathematics)

Course Objectives: The course aims to familiarize the learner with basic properties of Number theory, Fundamental theorem of arithmetic, Graph theory, Fuzzy set theory and it's simple application, Laplace transform and Fourier transform.

Course Learning Outcomes: After studying this course the student will be able to

- Grasp the basics of number theory, including the Fundamental Theorem of Arithmetic and apply divisibility rules, the properties of prime numbers, and techniques such as the Euclidean algorithm to compute greatest common divisors (GCDs),
- Solve simple Diophantine equations.
- Understand the concepts of graphs, paths, circuits, subgraphs, tree and simple application of graphs.
- Understand Laplace transform, Fourier transform and its application.
- Understand fuzzy set theory and its real life application.

Paper 6: MAT CC-06 (Complex Analysis)

Course Objective: In this course students will learn about the algebra and geometry of complex numbers, analyticity, contour integration as well as concepts of theorem like Cauchy, Morera, Liouville, Taylor's, Laurent's theorem etc. and this course will also develop the understanding about Power series, Residue & poles and conformal mapping.

Course Learning Outcomes: After studying this course the student will be able to

- Analyze the concept of differentiability, analyticity, Cauchy-Riemann equations and harmonic functions.
- Compute complex contour integrals for their applications in Cauchy integral theorem.
- Understand the concept of Liouville theorem, Rouche's theorem and fundamental theorem of algebra.
- Transform functions into power series, categorize singularities and poles.
- Understand the concept of Taylor's theorem and Laurent's theorem.
- Understand the concept of bilinear transformation and conformal mapping.

Paper 7: MAT CC07 (Differential and Integral Equations)

Course Objective: The objective of studying differential and integral equations is to provide a comprehensive understanding of modeling, analyzing, and solving equations involving derivatives (differential equations) and integrals (integral equations) of unknown functions. These equations are fundamental tools in describing a wide range of physical, engineering, and biological phenomena, including population dynamics, fluid flow, quantum mechanics, and signal processing.

Course Learning Outcomes: After studying this course the student will be able to

- Distinguish between different types of integral equations, such as Fredholm and Volterra equations, and between first- and second-kind integral equations.
- Understand the relationship between differential and integral equations, and when one can be transformed into the other.
- Learn solution techniques for integral equations, including the method of successive approximations (Picard iteration), Neumann series, and using resolvent kernels.
- Solve specific types of integral equations, including those with separable kernels.
- Study integral operators and their eigenvalues and eigen functions, which play a crucial role in solving both linear differential and integral equations.
- Grasp the fundamental theorems regarding the existence and uniqueness of solutions to differential and integral equations, including Picard's theorem for ODEs and Fredholm's alternative for integral equations.

Paper 8: MAT CC08 (Measure Theory)

Course Objectives: The main objective is to familiarize with the Lebesgue outer measure, Measurable sets, Measurable functions, Integration, Convergence of sequences of functions and their integrals, Functions of bounded variation, Lp-spaces.

Course Learning Outcomes: After studying this course the student will be able to

- Verify whether a given subset of R or a real valued function is measurable.

- Understand the requirement and the concept of the Lebesgue integral (a generalization of the Reimann integration) along its properties.
- Demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems and their applications.
- Know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations.
- Extend the concept of outer measure in an abstract space and integration with respect to a measure.
- Learn and apply Holder and Minkowski inequalities in Lp-spaces and understand completeness of Lp-spaces and convergence in measures.

Paper 9: MAT CC09 (Topology)

Course Objective: This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It is a central of modern analysis, and many further interesting generalizations of metric space have been developed.

Course Learning Outcomes: After studying this course the student will be able to
- Learn the compactness in metric space, Ascoli's theorem.
- Understand the concepts Topological spaces and they can apply the definition to construction of topological space and comparison of topologies.
- Understand the concepts of compactness along with Tychonoff's theorem.
- Learn the concepts and properties of the separation and importance of Uryshon's lemma, Tietze extension and Uryshon'smetrization theorem.
- Understand the concepts of Connectedness.

<u>Semester-III</u>

Paper 10: MAT CC10 (Number Theory)

Course Objective: The primary objective of studying number theory is to explore and understand the properties and behaviors of integers, prime numbers, divisibility, and their relationships. Number theory seeks to uncover patterns, solve equations involving whole numbers, and apply these findings to various branches of mathematics

Course Learning Outcomes: After studying this course the student will be able to
- Grasp the basics of number theory, including the Fundamental Theorem of Arithmetic
- Learn and apply divisibility rules, the properties of prime numbers, and techniques such as the Euclidean algorithm to compute greatest common divisors (GCDs).
- Understand and apply Fermat's Little Theorem and Euler's Theorem in solving number theoretic problems.
- Solve simple Diophantine equations, particularly linear ones, and apply these solutions to real-world problems involving integer solutions.
- Learn about quadratic residues, non-residues.

Paper 11: MAT CC11 (Functional Analysis)

Course Objective: To familiarize with the basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.

Course Learning Outcomes: After studying this course the student will be able to

- Learn about some kind of important inequalities like Cauchy's, Minskowski's and Holder's inequalities. And able to defined normed linear space, Banach space and their quotient space along with subspace.
- Understand the concept of continuous linear maps, B(N,N1).
- Learn about importance of Hahn-Banach theorem and consequences. And learn about the open mapping theorem and projection on Banach space.
- Learn in details about Hilbert's Space and Schwartz inequalities.

Paper 12: MAT CC12 (Fluid Dynamics)

Course Objectives: Prepare a foundation to understand the motion of fluid and develop concept, models and techniques which enables to solve the problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.

Course Learning Outcomes: After studying this course the student will be able to

- understand the concept of fluid and their classification, models and approaches to study the fluid flow.
- formulate mass and momentum conservation principle and obtain solution for non-viscous flow.
- know potential theorems, minimum energy theorem and circulation theorem.
- understand two dimensional motion, circle theorem and Blasius theorem.
- understand the concept of stress and strain in viscous flow.

Paper 13: MAT CC13 (Classical Mechanics)

Course Objectives: Students will be familiar with Newtonians mechanics and other form of mechanics based on principle of least action like Hamiltonian and Lagarangian mechanics. Students will learn four dimensional formulation, relativistic mechanics.

Course Learning Outcomes: After studying this course the student will be able to

- Will learn conservation laws, constraints, Lagrange's equations which are the basics for further study.
- Will be familiar with Lagarangian, Hamiltonian, which will be helpful for learning Quantum Mechanics.
- Will be familiar with Canonical transformations, Poisson Bracket, Equation of motion which will be helpful for further study.
- Will learn about small oscillation, Inertia tensor, rigid body which will be helpful to know about the motion of our galaxy, stars etc.
- Will learn about relativistic mechanics, covariant four dimensional formulation, covariant Lagrangian, Hamiltonian.

Paper 14: MAT CC14 (Optimization techniques)

Course Objective: This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, project planning and control with PERT-CPM, Integer programming and game theory etc.

Course Learning Outcomes: After studying this course the student will be able to

- Learn about the simplex method used to find optimal solutions of linear optimization.

- Write the dual of a linear programming problem.
- Solve the transportation and assignment problems.
- problems subject to certain constraints.
- Understand about inventory like known/probabilistic demand, deterministic model and probabilistic model without lead time.
- Find optimal solution of linear programming model using Game Theory.
- Find optimal solution of Integer programming and Gomory's cutting plane method.

Semester-IV

Paper 15: MAT CC-15 (Mathematical Methods)

Course Objective: The aim of this course is to give an introduction to the basic properties of PDEs and to the basic analytical techniques to solve them and examine the general structure of spaces by using techniques of the tensor analysis.

Course Learning Outcomes: After studying this course the student will be able to

- Develop a deep understanding of the concept of tensors as multidimensional arrays that generalize scalars, vectors, and matrices.
- Understand the distinction between covariant, contravariant, and mixed tensors, Grasp how tensors transform under a change of coordinates, both in terms of covariant and contravariant components.
- Understand the role of Christoffel symbols in defining connections on manifolds and in determining geodesics, the shortest paths between points in curved spaces.
- Recognize and classify different types of PDEs, such as elliptic, parabolic, and hyperbolic equations.
- Learn classical methods for solving PDEs, including separation of variables, Fourier series, and transform methods (e.g., Fourier and Laplace transforms).
- Apply these methods to solve problems involving heat conduction (heat equation), wave propagation (wave equation), and electrostatics (Laplace's and Poisson's equations).
- Formulate and solve initial value problems (IVPs) and boundary value problems (BVPs) for different types of PDEs.
- Solve special functions (Bessel, Hermite, Legendre).

Paper 16: MAT CC-16(Programming in C)

Course Objective: The course is designed to provide complete knowledge of C language. Students will be able to develop logics which will help them to create programs, applications in C. Also by learning the basic programming constructs they can easily switch over to any other language in future.

Course Learning Outcomes: After studying this course the student will be able to

- Understand the basics concepts of computer fundamentals and C programming to formulate simple algorithms and translate the algorithms to programs (in C language).
- Apply loop, decision making statement and functions to solve a given problem and also correct syntax and logical errors.
- Implement arrays, pointers, structures and union to formulate algorithms and programs and apply it for searching and sorting problems.
- Decompose a problem into functions and synthesize a complete program using divide

and conquer approach.

- Implement file handling in C programming for a given application.