SUBJECT: MATHEMATICS	
	After completion of the course students will be able to:
PROGRAMME OUTCOMES	PO1:-provide students with a comprehensive foundation in various mathematical disciplines, which includes Algebra, Linear Algebra, Real and Complex Analysis, Partial and Ordinary Differential Equations, Probability, Linear Programming Problems, Calculus, Discrete Mathematics, MATLAB and Numerical Analysis. PO2:-The Graduate Students will develop strong analytical and problem-solving skills, enabling them to tackle complicated mathematical problems and apply mathematical principles to real-world situations. PO3:- The program prepares students for diverse career opportunities in academia, industry, finance, and research, as well as for advanced studies in mathematics and related fields. PO4:- Through rigorous coursework and practical applications, students will gain proficiency in mathematical reasoning, computational techniques, and theoretical understanding
PROGRAMME SPECIFIC OUTCOMES	PSO1:-The undergraduate mathematics program in India aims to provide students with a comprehensive understanding of various mathematical disciplines. PSO2:- Students will master algebra, including groups, rings, fields and vector spaces; linear algebra, including matrix theory and Eigen values; and real and complex analysis, understanding limits, continuity, differentiation, integration, and analytic functions. PSO3:- They will learn to solve partial and ordinary differential equations, applying methods like separation of variables and transform techniques. PSO4:- The program covers probability theory, including random variables and distributions; linear programming problems, using methods like the simplex algorithm; and calculus, mastering differentiation and integration of functions. PSO5:- Students will also gain knowledge in discrete mathematics, covering logic, set theory, combinatory and graph theory, as well as numerical analysis, learning computational techniques for solving mathematical problems. PSO6:- prepare graduates for diverse careers in academia, industry, finance, research, and advanced studies in mathematics.

	COURSE OUTCOMES
	SEMESTER-I
CORE-I CALCULUS	CO1: Apply hyperbolic functions and higher-order derivatives to solve mathematical problems. CO2: Analyze concavity, inflection points and asymptotes and trace, Curves in Cartesian and polar coordinates. CO3: Utilize L' Hospital's rule to solve limit problems and integrate. Its applications in business, economics and life sciences. CO4: Evaluate integrals using Riemann integration, integration by parts, reduction formulas, and substitution methods. CO5: Compute volumes and arc lengths using slicing, disks, washers, cylindrical shells, and parametric equations, and classify conic sections.
CORE-II DISCRETE MATHEMATICS	CO1: Analyze sets, relations, and various mathematical properties and theorems, including equivalence relations, partial ordering, well- ordering and axiom of choice, Zorn's lemma, and the well-ordering property of positive integers. CO2: Apply the principles of mathematical induction, pigeonhole principle and principle of inclusion and exclusion to solve problems related to permutations, combinations, and the binomial and multinomial theorems, as well as recurrence relations and generating functions. CO3: Evaluate matrices and their properties, including determinants, minors, cofactors, ad joint, inverse, rank, and nullity, and solve systems of linear equations using row reduction and echelon forms, including finding Eigen values and eigenvectors. CO4: Examine graph theory concepts such as graph terminology, types of graphs, sub graphs, isomorphic graphs, adjacency and incidence matrices, paths, cycles, connectivity, Eulerian and Hamiltonian paths, and planar graphs. CO5: Utilize various mathematical tools and theorems, such as the division algorithm, Euclidean algorithm, congruence relations, modular arithmetic, Chinese remainder theorem, and Fermat's little theorem, to solve integer-related problems and construct logical arguments and proofs using truth tables and the algebra of propositions.
	SEMESTER-II
CORE--III REALANALYSIS	CO1: Understand the fundamental properties of the real number system, including order properties, bounds, and completeness, and apply the Bolzano-Weierstrass Theorem to sets. CO2: Analyze sequences and series, including their convergence and divergence, using various convergence tests and

	theorems such as Bolzano-Weierstrass and Cauchy's Convergence Criterion. CO3: Evaluate limits of functions using the epsilon-delta approach, and examine criteria for continuity, uniform continuity and related theorems such as Bolzano's Intermediate Value Theorem. CO4: Differentiate functions using rules and theorems such as Caratheodory's theorem and the Mean Value Theorem, and apply these to solve practical problems involving in equalities and extremum points. CO5: Synthesize the abstract concepts and rigorous methods of real analysis to solve practical mathematical problems involving sequences, series, limits, continuity and differentiability.
CORE--IV DIFFERENTIAL EQUATIONS	CO1: Understand and apply various types of solutions to differential equations, including exact, separable, linear, and Bernoulli's equations and use special integrating factors and transformations. CO2: Model real-world problems using differential equations, such as exponential ldecay, lake pollution, drugassimilation and population growth, and analyze these models qualitatively. CO3: Solve second-order homogeneous differential equations using the principle of super position, Wronskian and methods like undetermined coefficients and variation of parameters, and extend these methods to higher-order equations. CO4: Interpret phase planes and analyze models such as predatory-prey, epidemic, and battle models to understand equilibrium points and dynamics. CO5: Implement and simulate differential equation models using computational tools like MATLAB or Mathematica, and visualize the solutions to understand their behavior and implications in practical scenarios.
	SEMESTER-III
CORE--V THEORYOFREAL FUNCTIONS	CO1:ApplyL'Hospital'sRule, intermediate forms and Taylor's theorem to solve problems involving limits and utilize these tools to expand functions into Taylor and Maclaurin series. CO2: Understand Riemann integration, including the conditions for integrability and properties of the Riemann integral, and apply the Fundamental Theorems of Calculus to solve integrals.

	CO3: Evaluate improper integrals and analyze the convergence of Beta and Gamma functions, and determine the point wise and uniform convergence of sequences of functions. CO4: Analyze the convergence of series of functions using criteria like Cauchy's criterion and Weierstrass M-Test and apply theorems on the continuity, derivability, and integrability of limit functions. CO5: Investigate power series, including their radius of convergence, differentiation and integration and apply Abel's Theorem and the Weierstrass Approximation Theorem to practical problems.
CORE-VI GROUPTHEORY-I	CO1: Understand the basic concepts and properties of groups, including symmetries, Dihedral groups, permutation groups, and quaternion groups, and identify examples and subgroups. CO2: Analyze the structure and properties of cyclic groups, classify subgroups of cyclic groups and apply cycle notation for permutations, including the distinction between even and odd permutations. CO3: Apply Lagrange's theorem to understand the properties of cosets and explore the external direct product of groups, normal subgroups, and factor groups. CO4: Utilize Cauchy's theorem for finite abelian groups, understand group homeomorphisms and isomorphism's and apply Cayley's theorem and the first, second, and third isomorphism theorems. CO5: Extend the knowledge of group theory to solve problems in advanced mathematics courses and related fields such as physics, computer science, economics, and engineering.
CORE-VII PARTIALDIFFERENTAL EQUATIONSANDSYSTEMO FODEs	CO1: Understand and classify basic concepts and definitions of first-order partial differential equations (PDEs), and apply methods like characteristics and separation of variables to solve them. CO2: Derive and classify second-order linear equations such as the heat equation, wave equation, and Laplace equation, and reduce these equations to their canonical forms. CO3: Solve Cauchy problems and initial boundary value problems for PDEs, including non-homogeneous boundary conditions, using methods such as separation of variables.

	CO4: Analyze systems of linear differential equations, and apply operator methods to solve linear systems with constant coefficients, focusing on homogeneous linear systems. CO5: Implement solutions for PDEs and systems of ODEs using computational tools, and visualize solutions to understand their behavior in practical scenarios.
	SEMESTER-IV
CORE-VIII NUMERICALMETHODS AND SCIENTIFIC COMPUTING	CO1: Understand and apply error analysis and approximation techniques in scientific computing, including concepts of convergence, stability, and accuracy, and use appropriate numerical methods for solving non-linear equations. CO2: Solve systems of linear algebraic equations using methods such as Gaussian elimination, Gauss-Jordan, Gauss-Jacobi, and Gauss-Seidel, and analyze their convergence properties. CO3: Implement polynomial interpolation methods, including Lagrange, Newton, Hermite and spline interpolation, and evaluate errors in interpolation techniques. CO4: Apply numerical integration techniques, including Newton-Cotes rules, Trapezoidal rule, Simpson's rule and Richardson extrapolation, and perform numerical differentiation and integration using software tools. CO5: Develop and test numerical programs using computer-aided software (CAS) for various methods such as root-finding algorithms, linear system solvers, and interpolation techniques, and assess the accuracy and reliability of numerical results.
CORE-IX TOPOLOGYOFMETRICSPACES	CO1: Identify and analyze concepts related to metric spaces, including sequences, Cauchy sequences, completeness, and properties of open and closed sets. CO2: Understand and apply countability axioms, separability, and Baire’s Category Theorem in the context of metric spaces and subspaces. CO3: Examine and apply continuity concepts, including continuous mappings, uniform continuity, and extension theorems, and recognize homeomorphisms and equivalent metrics. CO4: Explore and apply contraction mappings, connectedness, local connectedness, and the properties of compact sets, and evaluate continuous functions on compact spaces. CO5: Develop foundational knowledge in topology of metric spaces, which prepare students for advanced courses in

	analysis and topology.
CORE-X RINGTHEORY	CO1: Define and explain the basic concepts of rings, including properties of rings, subrings, integral domains, and fields, and identify ideals and their operations. CO2: Analyze and apply properties of prime and maximal ideals, and understand ring homeomorphisms and the Isomorphism Theorems I, II, and III. CO3: Utilize polynomial rings over commutative rings, apply the division algorithm and examine principal ideal domains, polynomial factorization, and irreducibility tests. CO4: Discuss divisibility in integral domains, and examine concepts related to irreducibles, primes, unique factorization domains, and Euclidean domains. CO5: Prepare for advanced courses in ring theory and related algebraic structures by developing a solid foundation in modern algebraic concepts.
	SEMESTER-V
CORE-XI MULTIVARIATE CALCULUS	CO1: Calculate and analyze functions of several variables, including limits, continuity, partial derivatives and directional derivatives, and apply the chain rule for multiple independent parameters. CO2: Determine extrema of functions of two variables, use the method of Lagrange multipliers for constrained optimization and evaluate vector fields, divergence, and curl. CO3: Perform double and triple integrals, including in polar, cylindrical, and spherical coordinates, and apply these integrals for volume calculations and changing variables. CO4: Compute line integrals, apply them to physical contexts such as mass and work, and understand concepts of conservative vector fields and independence of path. CO5: Apply fundamental theorems of vector calculus, including Green's theorem, Stokes' theorem, and the Divergence theorem, to solve problems involving surface and volume integrals.
DSC PAPER –XII LINEARALGEBRA	CO1:Identify and work with vector spaces and subspaces, including linear combinations, linear independence, basis, and dimension, and analyze linear transformations, their null spaces, ranges, ranks, and nullities.

	CO2:Represent linear transformations using matrices, understand the algebra of linear transformations, isomorphism, and dual spaces, and compute matrix representations, inverses, and changes of coordinates. CO3:Computeeigen values and eigen vectors, determine diagonalizability, and apply the Cayley-Hamilton theorem. Perform orthogonalization using the Gram-Schmidt process and analyze inner product spaces. CO4:Apply concepts of orthogonal complements, Bessel's inequality, and least squares approximation. Work with normal and self-adjoint operators, and apply the Spectral theorem for understanding orthogonal projections and solving linear systems.
DSE –I LINEAR PROGRAMMING	CO1: Understand the theory of the simplex method, including optimality and unboundedness; and apply the simplex algorithm in tableau format. CO2: Analyze the Fundamental Theorem of Duality and its economic interpretation and apply duality concepts to solve practical linear programming problems. CO3: Understand the mathematical formulation of transportation and assignment problems. CO4: Analyze game theory using linear programming.
DSE-2 Probability ansstatistics	CO1: Understand and analyze basic concepts in probability, including probability distributions, expected value, variance and standard deviation. Apply these concepts to solve problems involving discrete and continuous random variables. CO2: Apply probability rules and theorems, such as Bayes' Theorem and the Law of Large Numbers, to solve real-world problems. Understand the concept of independence and conditional probability. CO3: Perform hypothesis testing and confidence interval estimation for population parameters. CO4: Understand and apply regression analysis and correlation to examine relationships between variables. Use techniques like linear regression. Understand the basic of GAME Theory
	SEMESTER-VI
CORE-XIII COMPLEX ANALYSIS	CO1: Understand the basic properties of complex numbers and the complex plane. Analyze continuous and holomorphic functions, perform integration along curves, and work

	with power series. CO2: Apply Cauchy's Theorem and Goursat's Theorem to evaluate complex integrals. Utilize Cauchy's integral formulas for practical computations and solve problems involving local existence of primitives. CO3: Explore Morera's Theorem and sequences of holomorphic functions. Apply the Schwarzreflection principle and analyze zeros and poles of holomorphic functions. CO4: Examine meromorphic functions and the residue formula. Apply the argument principle to solve problems and work with the complex logarithm.
CORE-XIV GROUP-THEORY-II	CO1: Understand and analyze automorphisms, including inner automorphisms and automorphism groups of finite and infinite cyclic groups. Apply factor groups to automorphism groups and explore characteristic subgroups. CO2: Investigate the commutator subgroup, its properties, and the fundamental theorem of finite abelian groups. Examine external and internal direct products, and understand the structure of the group of units modulo. CO3: Explore group actions, including stabilizers, kernels, and permutation representations. Apply group actions to derive generalized Cayley's theorem and the index theorem. CO4: Analyze groups acting on themselves by conjugation, using the class equation and its consequences. Apply Sylow theorems to study p-groups, and understand conjugacy in symmetric groups (S_n). Prove results such as the simplicity of $A_n, n \geq 5$ and test for non- simplicity.
DSE-3 Differential Geometry	CO1: Understand: Explain the concepts of osculating circles and spheres, and the existence of space curves and Use Serret-Frenet formulas to analyze space curves. CO2: Investigate evolutes, involutes, and the theory of surfaces. CO3: Explore principal and Gaussian curvatures, and developables CO4: Analyze geodesics and the Gauss-Bonnet theorem
GENERIC ELECTIVE	
GE-I CALCULUS AND DIFFERENTIAL	CO1: Use techniques to analyze and solve problems involving the geometry of curves and surfaces.

EQUATIONS	CO2: Apply fundamental concepts of single-variable calculus. CO3: Understand: Explain the Mean Value Theorem, Taylor's theorem, Maclaurin's theorem for functions of two variables, maxima and minima of functions of two and three variables, implicit functions, and Lagrange's multipliers. CO4: Analyze and solve ordinary differential equations (ODEs)
GE-II ALGEBRA	CO1: Understand and analyze the foundational concepts of sets, relations, and functions. CO2: Explore the properties and operations related to integers. CO3: Analyze and solve problems involving matrices and linear systems CO4: Use linear transformations, matrix representations, and