Krishnagar Government College
Department of Mathematics

Programme Name : B.Sc. in Mathematics

PROGRAM OUTCOMES

After completion of the programme, a student of B.Sc., will be able to

1. Possess the basic subject knowledge required for higher studies, and professional and applied courses like Financial Mathematics, Management Studies, etc.
2. Grasp the fundamental principles of logical thinking and reasoning.
3. Pursue research work in various emerging fields of mathematics and its applications.
4. Utilize logical and reasoning abilities, problem-solving proficiency, and effective communication skills for employment and various entrepreneurial endeavours.

PROGRAM SPECIFIC OUTCOMES

1. Fostering students' enthusiasm for mathematics by emphasizing its captivating and worthwhile nature
2. Students should receive comprehensive exposure to global and local issues that delve into various facets of mathematical sciences

3. Students will acquire mathematical modeling skills, problem-solving abilities, creative talents, and effective communication prowess essential for diverse employment opportunities and entrepreneurship
4. Students should demonstrate the ability to convert verbal information into mathematical representations, choose suitable mathematical methods or formulas, and analyze the data to arrive at meaningful conclusions.
5. Students will grasp fundamental mathematical theories and demonstrate familiarity with conventions, including notations and terminology.

Mathematics UG (CBCS) Semester-I

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
MATH-H-CC-T-01	Calculus & Analytical Geometry	6	75	After completion of this course, a student will be able to understand Hyperbolic functions and its derivative, higher order derivatives, Leibnitz rule and its applications to varius functions, Pedal equations, Curvature, radius of curvature, centre of curvature, circle of curvature. Asymptotes, Singular points, concavity and inflection points. Curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences, Reduction formulae in Calculus, and Transformation of coordinate axes, pair of straight lines, reflection properties of conics, canonical form second degree equations, classification of conics using the discriminant, polar equations of conics, Straight lines in 3D, sphere, cylindrical surfaces. central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics in Analytical Geometry.
MATH-H-CC-T-02	Algebra	6	75	After completion of this course, a student will be able to understand Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications, Direct and inverse circular form of trigonometric and hyperbolic functions, Exponential & Logarithm of a complex number, Relation between roots and coefficients, transformation of equation, Descartes rule of signs, solution of cubic equation (Cardan's method), Well-ordering property of positive integers, division algorithm, Euclidean algorithm. Congruence relation between integers. Principles of mathematical induction, statement of fundamental theorem of arithmetic, Equivalence relations and partitions. Functions, cardinality of a set, Permutations, Elementary group theory, Order of an element, order of a group and its properties, Orthogonal matrix and its properties. Rank of a matrix, inverse of a matrix, characterizations of invertible matrices, Row reduced and echelon forms, Normal form and congruence operations, Solutions of systems of linear equations and their applications.

MATH-H-GE-T-01/ MATH-H-GE-T-03 / MATH-G-CC-T-01	Algebra & Analytical Geometry	6	75	After completion of this course, a student will be able to understand Complex numbers, De Moivre's theorem and its applications, Exponential, Sine, Cosine and Logarithm of a complex number, Inverse circular and hyperbolic functions, Polynomials: Fundamental theorem of algebra Polynomials with real coefficients, Statement of Descartes rule of signs and its applications, Relation between roots and coefficients, transformations of equations. Cardan's method. Rank of a matrix. System of linear equations with not more than 3 variables. Equivalence relations and partitions. Functions and cardinality of a set , Elementary group Theory and Transformations of rectangular axes. Invariants. General equation of second degree, Canonical forms. Classification of conics. Pair of straight lines. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic. Polar equation of straight lines, circles, a conic refers to a focus as a pole, chord joining two points, tangents and normals.

Mathematics UG (CBCS) Semester-II

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
Mathematics-UG Paper-MATH-H-CC-T-043 (Theory) Sem-II	Real Analysis	6	75	After completion of this course, a student will be able to understand the natural numbers, Peano's axioms. algebraic and order properties of $\mathbb{R}$. Bounded sets, unbounded sets. L.U.B. and G.L.B. of a set and its properties. L.U.B. axiom or order completeness of $\mathbb{R}$. Countable and uncountable sets, uncountability of $\mathbb{R}$ and Countability of $\mathbb{Q}$. The Archimedean property, density of rational (and irrational) numbers in $\mathbb{R}$. Intervals, neighbourhood of a point in $\mathbb{R}$, interior points and open sets, limit points and closed sets, isolated points, adherent point, derived set, closure of a set, interior of a set. Illustrations of BolzanoWeierstrass theorem for sets. Upper and lower limits of a subset of R. Compact set in $\mathbb{R}$. Lindelöf covering theorem Heine-Borel theorem and its application. Sequences, bounded sequence, convergent sequence, limit of a sequence,liminf x_n, limsup x_n . Limit theorems. Sandwich theorem. Nested interval theorem. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only). Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion, Cauchy's 1st and 2nd limit theorems. Infinite series, convergence and divergence of infinite series, Cauchy criterion. Tests for convergence: comparison test, limit comparison test, ratio test: D'Alembert's ratio test, Raabe's test, Cauchy's root test, Gauss test (Statement only), integral test, Cauchy's condensation test. Alternating series.

MATH-H-CC-T-04	Differential Equations	6	75	After completion of this course, a student will be able to understand Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Separable equations. Exact differential equations and integrating factors. Linear equation and Bernoulli equations, special integrating factors and transformations. First order and higher degree differential equations, solvable for x , y and p , Clairaut's Equations. Lipschitz condition and Picard's Theorem , General solution of homogeneous equation of second order, principle of superposition for homogeneous equation. Wronskian, linear homogeneous and nonhomogeneous equations of higher order with constant coefficients. Euler's equation, method of undetermined coefficients. Method of variation of parameters. Systems of linear differential equations. Types of linear systems. Differential operators. An operator method for linear systems with constant coefficients. Basic Theory of linear systems in normal form. Homogeneous linear systems with constant coefficients, two Equations in two unknown functions. Equilibrium points. Interpretation of the phase plane. Power series solution of a differential equation about an ordinary point, solution about a regular singular point. Partial differential equations – Basic concepts and definitions. Mathematical problems. First- order equations, Lagrange's method, Charpit's method. Method of characteristics. Canonical forms. Method of separation of variables.
MATH-H-GE-T-02/ MATH-H-GE-T-04 / MATH-G-CC-T-02	Calculus & Differential Equations	6	75	After completion of this course, a student will be able to understand Real-valued functions defined on an interval, limit and Continuity of a function , Algebra of limits. Differentiability of a function. Successive derivative Leibnitz's theorem and its applications. Partial derivatives. Euler's theorem. Indeterminate Forms L'Hospital's Rule Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Taylor's and Maclaurin's infinite series of functions. Application of the principle of maxima and minima for a function of a single variable. Reduction formulae, derivations and illustrations of reduction formulae. First order equations: (i) Exact equations and those reducible to such equations. (ii) Euler's and Bernoulli's equations (Linear). (iii) Clairaut's Equations General and Singular solutions. Second order differential equation: (i) Method of variation of parameters, (ii) Method of undetermined coefficients.

Mathematics UG (CBCS) Semester-III

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
MATH-H-CC-T-05	Theory of Real & Vector Functions	6	75	After completion of this course, a student will be able to understand Limits of functions. Sequential criterion for limits. Divergence criteria. Limit theorems. Infinite limits and limits at infinity. Continuous functions, neighbourhood property. Sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, Bolzano's Theorem, intermediate value theorem. Location of roots theorem, preservation of intervals theorem. Uniform continuity. Differentiability of a function. Caratheodory's theorem. Algebra of differentiable functions. Darboux's theorem. Rolle's theorem, Lagrange's and Cauchy's mean value theorems. Taylor's theorem with Lagrange's and Cauchy's forms of remainder and its application to convex functions. Applications of mean value theorem to inequalities and approximation of polynomials. Relative extrema, interior extremum theorem. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions 1 $\log(1+x)$, $(1+x)^n$. Application of Taylor's theorem to inequalities. Vector products, Introduction to vector functions, operations with vector-valued functions. Limits and continuity of vector functions, Differentiation and integration of vector functions.
MATH-H-CC-T-06	Group Theory-I	6	75	After completion of this course, a student will be able to understand Subgroups, Cyclic group. Cosets and their properties. Lagrange's theorem and consequences including Fermat's little theorem. External direct product of a finite number of groups. Centre of a group, centralizer, normalizer. Normal subgroups. Factor groups. Cauchy's theorem for finite abelian groups. Group homomorphisms, basic properties of homomorphisms. Cayley's theorem. Properties of isomorphisms. First, second and third isomorphism theorems.

MATH-H-CC-T-07 (Theory & Practical)	Numerical Methods (Theory) & Numerical Methods Lab	6	75	After completion of this course, a student will be able to understand Algorithms, convergence, errors, relative, absolute, round-off, truncation errors. Interpolation, Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Central difference interpolation formula: Stirling and Bessel interpolation Numerical differentiation, methods based on interpolations, methods based on finite differences. Numerical integration, Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula. Transcendental and polynomial equations, bisection method, Newton's method, secant method, Regula Falsi method, fixed point iteration, Newton-Raphson method, rate of convergence of these methods. System of linear algebraic equations, Gaussian elimination and Gauss Jordan methods, Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU decomposition The algebraic eigenvalue problem, power method. Approximation, least square polynomial approximation. Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four. After completion of the course, students will be able to learn the following Programme under Numerical Methods (Lab): • LIST OF PRACTICAL PROBLEMS (Using 'C' or Python programming) i. Calculate the sum of infinite convergent series. ii. Find the absolute value of an integer. iii. Enter 100 integers into an array and sort them in an ascending order. iv. Bisection Method. v. Newton Raphson Method. vi. Secant Method. vii. Regula-Falsi Method. viii. LU decomposition Method. ix. Gauss-Jacobi Method. x. SOR Method or Gauss-Seidel Method. xi. Lagrange's Interpolation xii. Trapezoidal Rule.

MATH-H-SEC-T-1A	Programming in ‘C’	2	50	After completion of this course, a student will be able to understand Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: Binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc. Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems. Programming language and importance of ‘C’ programming. Constants, variables and data type of ‘C’-Program: Character set. Constants and variables data types, expression, assignment statements, declaration. Operation and expressions: Arithmetic operators, relational operators, logical operators. Decision statement, if-else statement, nesting if statement, switch statement, break and continue statement. Control statements: While statement, do-while statement, for statement. Arrays: One-dimension, two-dimensional and multidimensional arrays, declaration of arrays, initialization of one and multidimensional arrays. User-defined Functions: Definition of functions, scope of variables, return values and their types, function declaration, function call by value, nesting of functions, passing of arrays to functions, recurrence of function.
MATH-H-SEC-T-1B	Programming in Python	2	50	After completion of this course, a student will be able to understand Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc. Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems. Overview of programming: Structure of a Python Program, elements of Python. Introduction to Python: Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, identifiers and keywords, literals, strings, operators (Arithmetic operator, relational operator, logical or Boolean operator, assignment, operator, ternary operator, bit wise operator, increment or decrement operator). Creating Python Programs: Input and Output statements, control statements (branching, looping, conditional statement, exit function, difference between break, continue and pass), defining functions, default arguments.

MATH-G-CC-T-03	Real Analysis	6	75	After completion of this course, a student will be able to understand the natural numbers, Peano's axioms. algebraic and order properties of ℝ. Bounded sets, unbounded sets. L.U.B. and G.L.B. of a set and its properties. L.U.B. axiom or order completeness of ℝ. Countable and uncountable sets, uncountability of ℝ and Countability of ℚ. The Archimedean property, density of rational (and irrational) numbers in ℝ. Intervals, neighbourhood of a point in ℝ, interior points and open sets, limit points and closed sets, isolated points, adherent point, derived set, closure of a set, interior of a set. Illustrations of BolzanoWeierstrass theorem for sets. Upper and lower limits of a subset of R. Compact set in ℝ. Lindelöf covering theorem Heine-Borel theorem and its application. Sequences, bounded sequence, convergent sequence, limit of a sequence,liminf x_n, limsup x_n . Limit theorems. Sandwich theorem. Nested interval theorem. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only). Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion, Cauchy's $1^{st}$and 2^{nd} limit theorems. Infinite series, convergence and divergence of infinite series, Cauchy criterion. Tests for convergence: comparison test, limit comparison test, ratio test: D'Alembert's ratio test, Raabe's test, Cauchy's root test, Gauss test (Statement only), integral test, Cauchy's condensation test. Alternating series.
MATH-G-SEC-T-1A	Logic & Sets	2	50	After completion of this course, a student will be able to understand Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contrapositive and inverse propositions and precedence of logical operators. Propositional equivalence, Logical equivalences. Predicates and quantifiers: Introduction, quantifiers, binding variables and negations. Definition, examples and basic properties of ordered sets, maps
MATH-G-SEC-T-1B	Vector Calculus	2	50	After completion of this course, a student will be able to understand Vector products, Introduction to vector functions, operations with vector-valued functions. Limits and continuity of vector functions, Differentiation and integration of vector functions

Mathematics UG (CBCS) Semester-IV

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
MATH-H-CC-T-08	Ring Theory & Linear Algebra	6	75	After completion of this course, a student will be able to understand Definition of Ring. Properties of rings. Subrings. Integral domains and fields. Characteristics of a ring. Ideal. Factor rings. Operations on ideals. Prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III. Field of quotients. Concept of Vector space over a field: Examples, concepts of Linear combinations, linear dependence and independence of a finite number of vectors. Sub- space, concepts of generators and basis of a finite dimensional vector space. Replacement theorem. Extension theorem. Deletion theorem and their applications. Row space, column space. Euclidean Spaces. Orthogonal and orthonormal vectors. Gram-Schmidt process of orthogonalization. Linear transformations. Null space. Range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Eigenvalues, eigen vectors and characteristic equation of a matrix. Matric polynomials, Cayley-Hamilton theorem and its use in finding the inverse of a matrix. Diagonalization, Canonical forms.
MATH-H-CC-T-09	Multivariate Calculus & Tensor Analysis			After completion of this course, a student will be able to understand Functions of several variables, limit and continuity of functions of two or more variables. Differentiability and total differentiability. Partial differentiation. Sufficient condition for differentiability. Schwarz Theorems, Young's Theorems. Chain rule for one and two independent parameters. Homogeneous function and Euler's theorem on homogeneous functions and its converse. Jacobians and functional dependence. Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems. Double integration over a rectangular region. Double integration over non-rectangular regions. Double integrals in polar coordinates. Triple integrals. Triple integral over parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Directional derivatives. The gradient, maximal and normal property of the gradient. Line integrals, applications of line integrals: Mass and work. Fundamental theorem for line integrals, conservative

MATH-H-CC-T-10 / MATH-G-CC-T-04	Linear Programming Problems & Game Theory	6	75	After completion of this course, a student will be able to understand Introduction to linear programming problems. Mathematical formulation of LPP. Graphical solution. Convex sets. Basic solutions (B.S.) and non-basic solutions. Reduction of B.F.S from B.S Theory of simplex method. Optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of initial basic solution. Algorithms for solving transportation problems. Fundamentals of Game Theory
MATH-H-SEC-T-2A	Logic & Boolean Algebra	2	50	After completion of this course, a student will be able to understand Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contrapositive and inverse propositions and precedence of logical operators. Propositional equivalence, Logical equivalences. Predicates and quantifiers: Introduction, quantifiers, binding variables and negations. Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle. Lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials. Quinn-McCluskey method, Karnaugh diagrams, logic gates, switching circuits and applications of switching circuits.
-MATH-H-SEC-T-2B / MATH-G-SEC-T-2A	Graph Theory	2	50	After completion of this course, a student will be able to understand Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs isomorphism of graphs. Eulerian circuits, Eulerian graphs, semi-Eulerian graphs, Hamiltonian cycles. Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph. Travelling salesman's problem, shortest path, tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

Mathematics UG (CBCS) Semester-V

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
M A T H - H - CC-T-11	Riemann Integration and Series of Functions	6	75	After completion of this course, a student will be able to understand Riemann integration: inequalities of upper and lower sums, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition, Riemann integral through Riemann sums. Equivalence of two definitions. Riemann integrabilityof monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Fundamental theorem of integral calculus. 1^{st} and 2^{nd} mean value theorems for integral calculus. Improper integration: Type1, Type2. Necessary and sufficient condition for convergence of improper integral in both cases. Cauchy's Criterion. Cauchy's principal value. Tests of convergence: Comparison and m-test. Absolute and non-absolute convergence and. Abel's and Dirichlet's test for convergence on the integral of a product. Convergence of Beta and Gamma functions. Relation between Beta and Gamma functions and related problems. Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions. Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M -Test. Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem. Fourier series: Definition of Fourier coefficients and series, examples of Fourier expansions and summation results for series

M A T H - H - CC-T-12	Mechanics-I	6	75	After completion of this course, a student will be able to understand Motion in a straight line, under attractive and repulsive forces, under acceleration due to gravity. Simple harmonic motion. Motion in a resisting medium: Vertical and curvilinear motion in a resisting medium. Motion of varying mass. Work, Power and Energy. Conservative forces. Conservation of energy. Impulse and impulsive forces: Impulse of a force. Impulsive forces. Conservation of linear momentum. Collision of elastic bodies: Elasticity. Impact of smooth bodies. Impact on a fixed plane. Direct and oblique impact of two smooth spheres. Loss of kinetic energy. Angle of deflection. Motion in a Plane. Motion of a particle moving on a plane refers to a set of rotating rectangular axes. Angular velocity and acceleration. Circular motion. Tangential and normal accelerations. Central orbit. Areal velocity. Law of force for elliptic, parabolic and hyperbolic orbits. Velocity under central forces. Orbit under radial and transverse accelerations. Stability of nearly circular orbits. Planetary motion Newtonian law. Orbit under inverse square law. Kepler's laws of planetary motion. Time of description of an arc of an elliptic, parabolic and hyperbolic orbit. Effect of disturbing forces on the orbit. Artificial satellites. Degrees of freedom. Moments and products of inertia: Moment of inertia (M.I.) and product of inertia (P.I.) of some simple cases. M.I. about a perpendicular axis. Routh's rule. M.I. about parallel axes. M.I. about any straight line. M.I. of a lamina about a straight line in its plane. Momental ellipsoid. Equi-momental systems. General equations of motion D'Alembert's principle and its application to deduce general equations of motion of a rigid body. Motion of the centre of inertia (C.I.) of a rigid body. Motion relative to C.I. Motion about an axis. Equation of motion. K.E. of the body rotating about an axis. Compound pendulum and its minimum time of oscillation. Motion in two dimensions under finite forces. Two – dimensional of a solid of revolution down a rough inclined plane. Necessary and sufficient conditions for pure rolling.

MATH-H-DSE-T-1A	Group Theory-II	6	75	After completion of this course, a student will be able to understand Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups. Characteristic subgroups, Commutator subgroups and its basic properties, relationship with solvability of groups. Properties of external direct products, the group of units modulo *n* as an external direct product, internal direct products. Fundamental theorem of finite abelian groups. Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions: Generalized Cayley's theorem, Index theorem. Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p groups, Sylow's theorems and consequences. Cauchy's theorem, Simplicity of An, non-simplicity tests
MATH-H-DSE-T-1B	Partial Differential Equations & Laplace Transforms	6	75	After completion of this course, a student will be able to understand Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations. Reduction of second order linear equations to canonical forms. The Cauchy problem, Cauchy-Kovalevskaya theorem (Statement only), Cauchy problem of an infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem. One-dimensional diffusion equation and parabolic differential equations. Method of separation of variables. Solving the vibrating string problem and the heat conduction problem. Wave equation. Laplace Transform (LT) of Elementary functions. Properties of LTs: change of scale theorem, shifting theorem. LTs of derivatives and integrals of functions, derivatives and integrals of LTs. LT of Dirac Delta function, periodic functions. Convolution Theorem. Inverse LT. Application of Laplace transforms to solve ordinary and partial differential equations

MATH-H-DSE-T-2A	Number Theory	6	75	After completion of this course, a student will be able to understand Linear diophantine equation, prime counting function, statement of prime number theorem. Goldbach conjecture, linear congruences, complete set of residues. Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Statement of Fermat's Last theorem and their applications. Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function. Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function. Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots. Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli. Prime number and its properties. The arithmetic of $\mathbb{Z}_p$, p a prime, pseudo prime and Carmichael Numbers, Fermat Numbers, perfect numbers, Mersenne numbers. Public key encryption, RSA encryption and decryption, the equation $y^2 + x^2 = z^2$.
MATH-H-DSE-T-2B	Differential Geometry	6	75	After completion of this course, a student will be able to understand Space curves. Parametrised curves, arc length, regular curves, reparametrisation of space curves, curvature and torsion, planer curves, signed curvature of planer curves, curvature, torsion and Serret-Frenet formula. Osculating circles, osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves. Simple closed curves, isoperimetric inequality, four vertex theorem. Theory of surfaces: Definition of smooth surfaces, tangents normal and orientability, parametric curves on surfaces. Lengths of curves on surfaces, direction coefficients. First fundamental forms on surfaces. Curvature of surfaces: Second fundamental forms. Curvature of curves on surfaces, Principal and Gaussian curvatures. Normal curvature, lines of curvature, Meusnier's theorem, Euler's theorem. Developable surfaces: Developable surfaces, surfaces of constant mean curvature, minimal surfaces. Geodesics, equation of geodesics. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

M A T H - G - DSE-T-1A	Group Theory & Linear Algebra	6	75	After completion of this course, a student will be able to understand Subgroups, Cyclic group. Cosets and their properties. Lagrange's theorem and consequences including Fermat's little theorem. External direct product of a finite number of groups. Centre of a group, centralizer, normalizer. Normal subgroups. Factor groups. Cauchy's theorem for finite abelian groups. Concept of Vector space over a field: Examples, concepts of Linear combinations, linear dependence and independence of a finite number of vectors. Sub- space, concepts of generators and basis of a finite dimensional vector space. Replacement theorem. Extension theorem. Deletion theorem and their applications. Row space, column space. Euclidean Spaces. Orthogonal and orthonormal vectors. Gram-Schmidt process of orthogonalization. Linear transformations. Null space. Range, rank and nullity of a linear transformation, matrix representation of a linear transformation.
M A T H - G - DSE-T-1B	Complex Analysis	6	75	After completion of this course, a student will be able to understand Regions in the complex plane, stereographic projection, functions of complex variables, Limits, limits involving the point at infinity, continuity. Derivatives of functions, analytic functions, examples of analytic functions, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Complex integration: Curves in the complex plane, properties of complex line integrals, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula, problems relating to Cauchy's integral formula and its applications. Absolute and uniform convergence of power series, Taylor series and its examples. Laurent series and its examples

MATH-G-SEC-T-3A	Theory of Probability	2	50	After completion of this course, a student will be able to understand Sample space, probability axioms, real random variables (discrete and continuous). Probability distribution function, probability mass/density functions. Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial. Continuous distributions: uniform, normal, exponential, Beta, Gamma. Mathematical expectation, moments, moment generating function, characteristic function. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions. Expectation of function of two random variables, conditional expectations, independent random variables.
MATH-G-SEC-T-3B	Boolean Algebra	2	50	After completion of this course, a student will be able to understand Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle. Lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials. Quinn-McCluskey method, Karnaugh diagrams, logic gates, switching circuits and applications of switching circuits.

Mathematics UG (CBCS) Semester-VI

Course	Course Title	Credit	Full Marks	Course Outcomes (CO)
MATH-H-CC-T-13	Complex Analysis	6	75	After completion of this course, a student will be able to understand Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set. Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's intersection theorem. Subspaces, dense sets, separable spaces. Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Connectedness in metric space and its basic properties, connected subsets of $\mathbb{R}$. Compactness, sequential compactness, Heine-Borel property, countable compactness, totally bounded spaces, finite intersection property, continuous functions on compact sets. Regions in the complex plane, stereographic projection, functions of complex variables, Limits, limits involving the point at infinity, continuity. Derivatives of functions, analytic functions, examples of analytic functions, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Complex integration: Curves in the complex plane, properties of complex line integrals, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem (statement only), Cauchy integral formula, problems relating to Cauchy's integral formula and its applications. Absolute and uniform convergence of power series, Taylor series and its examples. Laurent series and its examples

MATH-H-CC-T-14	Probability & Statistics	6	75	After completion of this course, a student will be able to understand Sample space, probability axioms, real random variables (discrete and continuous). Probability distribution function, probability mass/density functions. Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial. Continuous distributions: uniform, normal, exponential, Beta, Gamma. Mathematical expectation, moments, moment generating function, characteristic function. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions. Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient. Linear regression for two variables. Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance. Random samples, sampling distributions. Estimation of parameters and estimate – consistent and biased. Maximum likelihood estimation. Applications to binomial, Poisson and normal populations. Confidence interval. Interval estimation for parameters of normal population. Confidence intervals for mean and standard deviation of a normal population. Approximate confidence limits for the parameter of a binomial population. Testing of hypotheses.
MATH-H-DSE-T-3A	Fuzzy Set Theory	6	75	After completion of this course, a student will be able to understand Interval numbers, arithmetic operations on interval numbers, distance between intervals, two level interval numbers. Fuzzy versus crisp sets, different types of fuzzy sets, cuts and its properties. Representations of fuzzy sets, decomposition theorems. Support, convexity, normality, cardinality of fuzzy sets. Standard settheoretic operations on fuzzy sets. Zadeh's extension principle. Types of fuzzy operations. Fuzzy complements, fuzzy intersections, fuzzy unions and their properties. Combinations of fuzzy operations. Crisp versus fuzzy relations. Fuzzy matrices and fuzzy graphs. Composition of fuzzy relations, relational joins. Fuzzy binary relations. Fuzzy numbers. Arithmetic operations on fuzzy numbers (multiplication and division on only). Fuzzy equations.

MATH-H-DSE-T-3B	Bio-Mathematics	6	75	After completion of this course, a student will be able to understand Mathematical biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth. Bacterial growth in a chemostat, harvesting a single natural population. Prey-predator systems and LotkaVolterra equations, populations in competitions, epidemic models (SI, SIR, SIRS). Activator-inhibitor system, Insect outbreak model. Qualitative analysis of continuous models: Linearization, equilibrium points, hyperbolic and nonhyperbolic equilibrium, Routh-Hurwitz criteria for stability. Interpretation of the phase plane. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenarios. Spatial models: One species model with one-dimensional diffusion. Two species model with one-dimensional diffusion. Conditions for diffusive instability, spreading colonies of microorganisms. Introduction to discrete models, Overview of difference equations, steady state solution and linear stability analysis. Linear models, growth models, decay models, drug delivery problem, discrete preypredator models, density dependent growth models with harvesting, host-parasitoid systems (NicholsonBailey model). Optimal exploitation models, models in genetics, stage-structure models, age-structure
MATH-H-DSE-T-4A	Point Set Topology	6	75	After completion of this course, a student will be able to understand Topological spaces, discrete and indiscrete topology, co-finite topology, co-countable topology. Basis and sub-basis for a topology, topology on a set generated by a family of subsets, metric topology, lower limit topology in $\mathbb{R}$. Neighbourhood of a point, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of set, dense subsets. Subspace topology, finite product topology. Continuous functions, open maps, closed maps, homeomorphisms. Net in a topological space and its convergence. First, second countable and separable spaces with examples and basic properties. Separation axioms, T_0, T_1 and T_2 spaces, regular topological spaces with examples, basic characterizations.

MATH-H-DSE-T-4B	Mechanics-II	6	75	After completion of this course, a student will be able to understand Coplanar forces: Reduction of a system of coplanar forces. Moment about any point as base. Equation of the line of resultant. Necessary and sufficient conditions of equilibrium. Astatic equilibrium .Principle of virtual work and its converse. Forces in three dimensions: Moment of a force about a line. Reduction of a system of forces in space. Poinsot's central axis. Equations of the central axis. Wrench and screw. Condition for a single resultant force. Centre of gravity: Centre of gravity of areas, surfaces and volumes (variation of gravity included). Pappus theorem (statement only). Stable and unstable equilibrium. Stability of equilibrium of two bodies other than spherical bodies. Energy test of stability. Condition of stability of equilibrium of a perfectly rough heavy body lying on a fixed body. Real and ideal fluids. Pressure of fluid. Transmission of fluid pressure. Elasticity. Specific gravity Pressure of heavy fluids: Magnitude of pressure at a point in a liquid. Pressure at all points at the same horizontal level in a liquid at rest under gravity. For a liquid in equilibrium under gravity, the difference of pressure between any two points is proportional to their depths. Free surface of a homogeneous in equilibrium under gravity is horizontal. Horizontal planes in a liquid in equilibrium under gravity are surfaces of equal density. Pressure at any point in the lower of two immiscible liquids in equilibrium under gravity; Surface of separation is a horizontal plane. Thrust of homogeneous liquids on the plane surface. Condition of equilibrium of fluids: Pressure derivative in terms of force. Pressure equation and the conditions of equilibrium. Surfaces of equal pressure. Fluid of equilibrium under gravity. Fluid in relative equilibrium. Rotating fluid. Centre of pressure: Definition, position of the centre.

MATH-G-DSE-T-2A	Dynamics of a Particle	6	75	Motion in a straight line, under attractive and repulsive forces, under acceleration due to gravity. Simple harmonic motion. Motion in a resisting medium: Vertical and curvilinear motion in a resisting medium. Motion of varying mass. Work, Power and Energy. Conservative forces. Conservation of energy. Impulse and impulsive forces: Impulse of a force. Impulsive forces. Conservation of linear momentum. Collision of elastic bodies: Elasticity. Impact of smooth bodies. Impact on a fixed plane. Direct and oblique impact of two smooth spheres. Loss of kinetic energy. Angle of deflection. Motion in a Plane. Motion of a particle moving on a plane refers to a set of rotating rectangular axes. Angular velocity and acceleration. Circular motion. Tangential and normal accelerations. Central orbit. Areal velocity. Law of force for elliptic, parabolic and hyperbolic orbits. Velocity under central forces. Orbit under radial and transverse accelerations. Stability of nearly circular orbits. Planetary motion Newtonian law. Orbit under inverse square law. Kepler's laws of planetary motion. Time of description of an arc of an elliptic, parabolic and hyperbolic orbit. Effect of disturbing forces on the orbit. Artificial satellites.
MATH-G-DSE-T-2B	Numerical Methods	6	75	After completion of this course, a student will be able to understand Algorithms, convergence, errors, relative, absolute, round-off, truncation errors. Interpolation, Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Central difference interpolation formula: Stirling and Bessel interpolation Numerical differentiation, methods based on interpolations, methods based on finite differences. Numerical integration, Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula. Transcendental and polynomial equations, bisection method, Newton's method, secant method, Regula Falsi method, fixed point iteration, Newton-Raphson method, rate of convergence of these methods. System of linear algebraic equations, Gaussian elimination and Gauss Jordan methods, Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU decomposition

MATH-G-SEC-T-4A	Programming in 'C'	2	50	After completion of this course, a student will be able to understand Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: Binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc. Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems. Programming language and importance of 'C' programming. Constants, variables and data type of 'C'-Program: Character set. Constants and variables data types, expression, assignment statements, declaration. Operation and expressions: Arithmetic operators, relational operators, logical operators. Decision statement, if-else statement, nesting if statement, switch statement, break and continue statement. Control statements: While statement, do-while statement, for statement. Arrays: One-dimension, two-dimensional and multidimensional arrays, declaration of arrays, initialization of one and multidimensional arrays. User-defined Functions: Definition of functions, scope of variables, return values and their types, function declaration, function call by value, nesting of functions, passing of arrays to functions, recurrence of function.
MATH-G-SEC-T-4B	Programming in Python	2	50	After completion of this course, a student will be able to understand Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc. Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems. Overview of programming: Structure of a Python Program, elements of Python. Introduction to Python: Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, identifiers and keywords, literals, strings, operators (Arithmetic operator, relational operator, logical or Boolean operator, assignment, operator, ternary operator, bit wise operator, increment or decrement operator). Creating Python Programs: Input and Output statements, control statements (branching, looping, conditional statement, exit function, difference between break, continue and pass), defining functions, default arguments.