Department of Mathematics

Syllabus (PG)M. Sc. Mathematics
(2020-21)

Semester-I

Paper – I (Code: 1T1)
Algebra –I

Unit I: Permutation Group. Normal subgroups, Quotient groups Dihedral group. Commutator group. Isomorphism Theorems. Automorphisms. Characteristic subgroup. Conjugacy and G-Sets, -Cyclic Decomposition - Alternating group An, Simplicity of An.
Unit II: Normal Series. Solvable groups. Nilpotent groups. Cyclic decomposition of permutation group. Alternating groups. Simplicity of An.

Unit III: Direct product, semi-direct product of groups, finitely generated abelian groups - Invariants of a finite abelian group, Sylows theorems. Groups of order 2 p and pq.

Unit IV: Ideals and Homomorphisms. Sum and direct sum of ideals. Maximal and prime ideals. Nilpotent and Nil ideals. Modules. Submodules. Direct sums. R-homomorphisms and quotient modules. Completely reducible modules. Free modules

Paper – II (Code: 1T2)

Real Analysis-I

Unit I: Uniform convergence. Uniform convergence and continuity. Uniform convergence and integration. Uniform convergence and differentiation. Equicontinuous families of functions. The Stone-Weierstrass theorem.

Unit II: Differentiation. The Contraction Principle. The Inverse Function Theorem. TheImplicit Function Theorem. The Rank Theorem. Partitions of unity.

Unit III: The space of tangent vectors at a point of Rn. Another definition of Ta (Rn). Vector fields on open subsets of Rn. Topological manifolds. Differentiable manifolds. Real Projective space. Grassman manifolds. Differentiable functions and mappings.

Unit IV: Rank of a mapping. Immersion. Sub manifolds. Lie groups. Examples of Lie groups.

Paper – III (Code: 1T3)
Topology-I

Unit I: Countable and Uncountable sets. Examples and related Theorems. Cardinal Numbers and related Theorems. Topological Spaces and Examples.

Unit II: Open sets and Limit points, Derived Sets. Closed sets and closure operators. Interior, Exterior and boundary operators. Neighbourhoods, bases and relative topologies.

Unit III: Connected sets and components. Compact and countably compact spaces. Continuous functions and homeomorphisms, Arc wise connectivity.

Unit IV: To and T1-spaces, T2-spaces and sequences. Axioms of countability. Separability. Regular and normal spaces.

Paper – IV (Code: 1T4)
Ordinary Differential Equations

Unit I: Linear Equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogenous equations, Homogeneous equations with analytic coefficients, The Legendre equations.

Unit - II: Linear Equations with regular singular points: The Euler equations, Second orderequations with regular singular points, The Bessel equation, Regular singular points at infinity.

Unit III: Existence and uniqueness of solutions to first order equations: The method of successive approximations, The Lipschitz condition of the successive approximation. Convergence of the successive approximation, non-local existence of solutions, Approximations to solutions and uniqueness of solutions.

Unit IV: Existence and Uniqueness of Solutions to System of first order ordinary differential equations: An example- Central forces and planetary motion, Some special equations, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence and uniqueness for linear systems, Green's function, Sturm Liouville theory.

Paper – V (Code: 1T5)

Integral Equations

Unit 1: Preliminary concepts of integral equations. Some problems which give rise to integral equations. Conversion of ordinary differential equations into integral equations. Classification of linear integral equations. Integro-differential equations.

Unit 2: Fredholm equations. Degenerate kernels. Hermitian and symmetric kernels. The Hilbert- Schmidt theorem. Hermitization and symmetrization of kernels. Solutions of integral equations with Green's function type kernels.

Unit 3: Types of Voltera equations. Resolvent kernel of Voltera equations, Convolution type kernels. Some miscellaneous types of Voltera equations. Non-linear Voltera equations. Fourier integral equations. Laplace integral equations.

Unit 4: Hilbert transform. Finite Hilbert transforms. Miscellaneous integral transforms. Approximate methods of solutions for linear integral equations. Approximate evaluation of Eigen values and Eigen functions.

Semester-II

Paper – VI (Code: 2T1)

Algebra-II

Unit I: Unique factorization domains. Principal Ideal domains. Euclidean domains. Polynomial rings over unique factorization domains.

Unit II: Irreducible polynomials and Eisenstein criterion. Adjunction of roots. Algebraic extensions. Algebraically closed fields. Splitting fields. Normal extensions. Splitting fields, multiple roots.

Unit III: Finite fields. Separable extensions. Automorphism groups, and fixed fields. Fundamental theorem of Galois theory. Fundamental theorem of algebra.

Unit IV: Roots of unity and Cyclotomic polynomials. Cyclic extensions. Polynomials solvable by radicals. Ruler and compass constructions.

Paper – VII (Code: 2T2)

Real Analysis -II

Unit I: Outer measure. Measurable sets and Lebesgue measure. Anon-measurable set, Measurable functions, Littlewood's three principles.

Unit II: The Riemann integral. Lebesgue integral of a bounded function over a set of finite measure. Integral of a non-negative function. General Lebesgue integral. Convergence in measure. Differentiation of monotone functions. Functions of bounded variation. Differentiation of an integral.

Unit III: Absolute continuity.Convex functions. Lp-spaces. Holder and Minkowski inequality. Riesz-Fischer theorem. Approximation in Lp. Bounded linear functionals on Lpspaces.

Unit IV: Compact metric spaces. Baire category theorem. Arzela Ascoli theorem. Locally compact spaces. Sigma compact spaces.

Paper – VIII (Code: 2T3)

Topology-II

Unit I : Continuous Functions: Continuous functions - the product topology - The metric topology.

Chapter 2 : Sections 18 to 21 [Omit Section 22]

Unit II: Connectedness: Connected spaces - connected subspaces of the Real line - Components and local connectedness. [Chapter 3 : Sections 23 to 25]

Unit III: Compactness: Compact spaces - compact subspaces of the Real line - Limit Point Compactness - Local Compactness. [Chapter 3 : Sections 26 to 29]

Unit IV: Countability And Separation Axiom: The Countability Axioms - The separation Axioms - Normal spaces - The Urysohn Lemma - The Urysohnmetrization Theorem - The Tietz extension theorem. [Chapter 4 : Sections 30 to 35]

Paper – IX (Code: 2T4)

Differential Geometry

Unit I: Definition of surface. Curves on a surface. Surfaces of revolution. Helicoids. Metric. Direction coefficients. Families of curves. Isometric correspondence. Intrinsic properties. Geodesics. Canonical geodesic equations.

Unit II: Normal property of geodesics. Existence theorems. Geodesic parallels. Geodesic curvature. Gauss Bonnet theorem. Gaussian curvature. Surfaces of constant curvature. Conformal mapping. Geodesic mapping.

Unit III: Second fundamental form. Principal curvatures. Lines of curvature. Developable. Developable associated with space curves. Developable associated with curves on surfaces. Minimal surfaces and ruled surfaces. Fundamental equations of Surface theory. Parallel surfaces.

Unit IV: Compact surfaces whose points are umbilics. Hilbert's lemma. Compact surfaces of constant Gaussian or mean curvature. Complete surfaces. Characterisation of complete surfaces. Hilbert's theorem. Conjugate points on geodesics. Intrinsically defined surfaces. Triangulation. Two dimensional Riemannian manifolds. Problem of metrization. Problem of continuation.

Paper – X (Code: 2T5)

Classical Mechanics

Unit I: Variational principle and Lagrange's Equations: Hamilton's principle, some techniques of the calculus of variations. Derivation of Lagrange' s Equations from Hamilton's Principle. Extension of principle to nonholonomic systems. Conservation theorems and symmetry properties.

Unit II: Legendre transformations and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's equations, Derivation of Hamilton's equations from a variational principle, the principle of least action.

Unit III: Canonical transformations: The equations of Canonical transformation, examples of canonical transformations. Symmetric approach to Canonical Transformation, Poisson's bracket & other canonical invariants.

Unit IV: Equations of motion. Infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, the angular momentum poisson bracket relations, Hamilton-Jacobi theory for Hamilton's principle, and Hamilton-Jacobi theory for characteristic functions.

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Semester-III

Paper – XI (Code: 3T1)
Complex Analysis

Unit I: Impossibility of ordering Complex numbers. Extended complex plane andstereographic projection. Elementary properties and examples of analytic Functions: Power series, analytic functions.

Unit II: Analytic functions as mappings, Mobius transformations. Power series representation of analytic functions, zeros of an analytic function, index of aclosed curve.

Unit III: Cauchy's theorem and integral formula, the homotopic version of cauchy'stheorem and simple connectivity, counting zeros; the open mapping theorem, Goursat's theorem, Classification of singularities, residues, the argument principle.

Unit IV: The maximum principle. Schwarz's lemma. convex functions and Hadamards three circles theorem. Phragmen-Lindel of theorem.

Paper – XII (Code: 3T2)
Functional Analysis

Unit I: Normed spaces, Banach spaces, Further properties of normed spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded and continuous linear operators.

Unit II: Linear functionals. Normed spaces of operators. Dual spaces. Inner product space. Hilbert space. Further properties of inner product spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Total orthonormal sets and sequences.

Unit III: Representation of functionals on Hilbert spaces. Hilbert adjoint operators, self-adjoint, unitary and normal operators. Hahn-Banach Theorem, Hahn-Banach Theorem for complex vector spaces and normed spaces. Reflexive spaces.

Unit IV: Category theorem, Uniform boundedness theorem, strong and weak convergence,Convergence of sequences of operators and functionals. Open mapping theorem, Closed linear operators and closed graph theorem.

Paper – XIII (Code: 3T3)

Mathematical Methods

Unit I: Fourier integral theorem. Fourier transform. Fourier cosine and sine transform. The convolution integral. Multiple Fourier transform. Solution of partial differential equation by means of Fourier transform.

Unit II: Calculations of the Laplace transform of some elementary functions. Laplace transforms of derivatives. The convolution of two functions. Inverse formula for the Laplace transform. Solutions of ordinary differential equations by Laplace transform.

Unit III: Finite Fourier transform. Finite Sturm-Liouville transforms. Generalized finite Fourier transform.

Unit IV: Finite Hankel transform. Finite Legendre transform. Finite Mellin transform.

Core Elective
Paper – XIV (Code: 3T4)
Fluid Dynamics-I

Unit I: Real fluids and ideal fluids. Velocity of a fluid at a point. Stream lines and path lines. Steady and unsteady flows. Velocity potential. Velocity vector. Local and particle rate of change. Equation of continuity. Acceleration of a fluid. Condition at a rigid boundary. General analysis of fluid motion. Euler's equation of motion. Bernoulli's equation. Worked examples. Discussion of the case of steady motion under conservative body forces. Some further aspects of vortex motion.

Unit II: Sources, sinks and doublets. Images in a rigid infinite plane. Images in solid spheres. Axisymmetric flows. Stokes' stream function. The complex potential for twodimensional irrotational,incompressible flow. Complex velocity potential for standard two-dimensional flow. Uniform stream. Line source and line sink. Line doublets. Line vortices. Two-dimensional image systems. The Milne-Thomson circle theorem. Circle Theorem. Some applications of circle theorem. Extension of circle theorem. The theorem of Blasius.

Unit III:

The equations of state of a substance, the first law of thermodynamics, internal energy of a gas, functions of state, entropy, Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes. Compressibility effects in real fluids, the elements of wave motion. One dimensional wave equation, wave equation in two and three dimensions, spherical waves, progressive and stationary waves.

Unit IV:

The speed of sound in a gas, equation of motion of a gas. Sonic, subsonic, supersonic flows; isentropic gas flow. Reservoir discharge through a channel of varying section, investigation of maximum mass flow through a nozzle, shock waves, formation of shock waves, elementary analysis of normal shock waves.

CORE SUBJECT CENTRIC (Only Students of Mathematics)

Paper – XIV (Code: 3T5)
Operations Research–I

Unit I: Operations Research: Origin, Definition and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two-phase methods, Degeneracy, Duality in linear programming.

Unit II: Transportation Problems: Basic feasible solutions, Optimum solution by stepping stone andmodified distribution methods, Unbalanced and degenerate problems, Transhipment problem.Assignment problems: Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.

Unit III: Concepts of stochastic processes, Poisson process, Birth-death process, Queuing models: Basic components of a queuing system, Steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/MC/k).

Unit IV: Inventory control models: Economic order quantity (EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

Semester-IV

Paper – XVI (Code: 4T1)

Dynamical Systems

Unit I: Dynamical systems and vector fields. The fundamental theorem. Existence and uniqueness. Continuity of solutions in initial conditions. On extending solutions. Global solutions. The flow of a differential equation.

Unit II: Nonlinear sinks. Stability. Liapunov function. Gradient systems. Gradients and inner products.

Unit III: Limit sets, local sections and flow boxes, monotone sequences in planar dynamical systems. The Poincare Bendixson theorem, Applications of Poincare Bendixson theorem; one species, predator and prey, competing species.

Unit IV: Asymptotic stability of closed orbits, discrete dynamical systems. Stability and closed orbits. Non autonomous equations and differentiability of flows. Persistence of equilibria, persistence of closed orbits. Structural stability.

Paper – XVII (Code: 4T2)

Partial Differential Equations

Unit I: Curves and surfaces, First order Partial Differential Equations, classification of first order partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible systems of first order partial differential equations.

Unit II: Charpits method, Jacobi method of solving partial differential equations, Integral surfaces through a given curve for a linear partial differential equation: Cauchy Problem, Quasi Linear Equations: Geometry of Solutions, Non-linear First Order partial differential equations.

Unit III: Second order Partial Differential Equations, Classification of second order partial differential equation, Vibration of an infinite string (both ends are not fixed), Physical Meaning of the solution of the wave equation. Vibration of a semi-infinite string, Vibration of a string of finite length:(Method of separation of variables), Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod.

Unit IV: Laplace equation, Boundary Value Problems: Dirichlet's problems and Neumann problems, Maximum and minimum principles. Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Families to equipotential surfaces, Solution of Laplace equation, Laplace equation in polar form, Laplace equation in spherical polar coordinates. Kelvin's inversion theorem, Stability theorem, Duhamel's Principle.

Paper – XVIII (Code: 4T3)

Advance Numerical Methods

Unit I: Simple enclosure methods, Secant method, Newton's method, general theory for one point iteration methods. Aitken extrapolation for linearly convergent sequences, Error tests, Numerical evaluation of multiple roots, roots of polynomials, Mullers method, Non-linear systems of equations, Newton's method for non- linear systems.

Unit II: Polynomial interpolation theory, Newton's divided differences, finite difference and table-oriented interpolation formulas. Forward-differences. Hermite interpolation.

Unit III: The Weierstrass theorem and Taylor's theorem. The minimax approximation problem, the least square approximation problem, orthogonal polynomial, economisation of Taylor series, minimax approximation.

Unit IV: The trapezoidal rule and Simpson's rule, Newton- Cotes integration formulas.

Core Elective

Paper – XIX (Code: 4T4)

Fluid Dynamics-II

Unit I: Stress components in a real fluid, relation between Cartesian components of stress translation motion of fluid elements, the rate of strain quadric and principal stresses, some further properties of the rate of the strain quadric, stress analysis in fluid motion, relation between stress and rate of strain, the coefficient of viscosity and laminar flow, the Navier-Stokes equations of motion of a viscous fluid, some solvable problems in viscous flow, diffusion of vorticity, energy dissipation due to viscosity, steady flow past a fixed sphere.

Unit II: Nature of magneto-hydrodynamics, Maxwell electromagnetic field equations; Motion at rest, Motion in medium, Equation of motion of conducting fluid, Rate of flow of charge, Simplification of electromagnetic field equation. Magnetic Reynold number; Alfven's theorem, The magnetic body force. Ferraro's Law of Isorotation.

Unit III: Dynamical similarity, Buckingham Theorem. Renold number. Prandtl's boundary layer, Boundary layer equation in two dimensions, Blasius solutions, Boundary layer thickness, Displacement thickness. Karman integral conditions, Separation of boundary layer flow.

Unit IV: Turbulence: Definition of turbulence and introductory concepts. Equations of motion for turbulent flow. Reynolds Stresses Cylindrical coordinates. Equation for the conservation of a transferable scalar quantity in a turbulent flow. Double correlations between turbulence-velocity components. Change in double velocity correlation with time. Introduction to triple velocity correlations. Features of the double longitudinal and lateral correlations in a homogeneous turbulence. Integral scale of turbulence.

CORE SUBJECT CENTRIC (Only Students of Mathematics)

Paper – XX (Code: 4T5)

Operations Research–II

Unit I: Revised simplex method (with and without artificial variables). Post Optimality Analysis: changes in (i) objective function, (ii) requirement vector, (iii) coefficient matrix; Addition and deletion of variables, Addition of constraints.

Unit II: Integer Programming: Gomory's cutting plane algorithm (All integer and mixed integer algorithms), Branch and Bound method.

Unit III: Bounded variable technique for L.P.P. Unconstrained optimization, Constrained optimization with equality constraints- Lagrange's multiplier method, Interpretation of Lagrange multiplier.

Unit IV: Inventory control: Deterministic inventory models including price breaks. Multi-item inventory model with constraints. Queueing Theory: Basic features of queueing systems, operating characteristics of a queueing system, arrival and departure (birth & death) distributions, inter-arrival and service times distributions, transient, steady state conditions in queueing process. Poisson queueing models- M/M/1, M/M/C for finite and infinite queue length.