The University of Burdwan

Syllabus for
3-year B.A. /B.Sc. (Honours)Course
(1+1+1 Pattern)
in
MATHEMATICS
(With effect from 2015-2016 onward)

[One hour lecture (1L) per one mark]

Part –I

Paper – I :	Group A: Classical Algebra	30 Marks (30 L)
	Group B: Abstract Algebra-I	30 Marks (30 L)
	Group C: Geometry of two dimensions	15 Marks (15 L)
	Group D: Geometry of three dimensions	25 Marks (25 L)
Paper –II :	Group A: Analysis-I	30 Marks (30 L)
	Group B: Integral Calculus	20 Marks (20 L)
	Group C: Ordinary Differential Equations	40 Marks (40 L)
	Group D: Partial Differential Equations	10 Marks (10 L)

Part –II

Paper – III :	Group A: Abstract Algebra-II	20 Marks (20 L)
	Group B: Linear Algebra	30 Marks (20 L)
	Group C: Number Theory	20 Marks (20 L)
	Group D: Analysis-II	30 Marks (30 L)
Paper –IV :	Group A: Vector Analysis	30 Marks (30 L)
	Group B: Dynamics of a Particle	50 Marks (50 L)
	Group C: Tensor Calculus	20 Marks (20 L)

Part –III

Paper – V :	Group A: Analysis-III	50 Marks (50 L)
	Group B: Complex Analysis	20 Marks (20 L)
	Group C: Metric spaces	30 Marks (30 L)
Paper –VI :	Group A: Elements of Continuum Mechanics	10 Marks (10 L)
	Group B: Classical Dynamics, Dynamics of a system of particles and rigid body	40 Marks (40 L)

	Group C: Statics	20 Marks (20 L)
	Group D: Hydrostatics	30 Marks (30 L)
Paper – VII :	Group A: Mathematical Probability	40 Marks (40 L)
	Group B: Statistics	20 Marks (20 L)
	Group C: Operations Research	40 Marks (40 L)
Paper –VIII :	Group A: Numerical Analysis	35 Marks (35 L)
	Group B: Computer programming	15 Marks (15 L)
Paper –IX :	Computer Aided Numerical Practical	50 Marks (50 L)

Part –I

Paper – I

Group – A

Classical Algebra (30 Marks)

Inequalities: Arithmetic mean, geometric mean and harmonic mean; Schwarz inequality and Weierstrass's inequality. Simple continued fraction and its convergence, representation of real numbers.

Complex numbers: De Moivre's theorem, roots of unity, exponential function, Logarithmic function, Trigonometric function, hyperbolic function and inverse circular function. Summation of Series.

Polynomial: polynomial equation, Fundamental theorem of algebra (statement only), multiple roots, statement of Rolle's theorem only and its application, equation with real coefficients, complex roots, Descarte's rule of sign, relation between roots and coefficients, transformation of equation, Reciprocal equations, special roots of unity, solution of cubic equations- Cardan's method, solution of biquadratic equation – Ferrari's method.

Group – B

Abstract Algebra – I (30 Marks)

Prerequisite: [Surjective, injective and bijective mapping, composition of two mappings, inverse mapping, extension and restriction of mappings, equivalence relation].

Partition of a set, countable and uncountable sets, countability of rational numbers and uncountability of real numbers.

Group: Definition, examples, subgroups, necessary and sufficient condition for a nonempty set to be a subgroup, generator of a group and a subgroup, order of a group and order of an element, Abelian group.

Permutation group, cycles, length of a cycle, transposition, even and odd permutation, alternating group, important examples such as S_3 and K_4 (Klein 4-group).

Cyclic subgroups of a group, cyclic groups and their properties, groups of prime order, coset, Lagrange's theorem.

Ring, subring, integral domain, elementary properties, field, subfields, characteristic of a field or integral domain, finite integral domain, elementary properties.

Group C

Geometry of two dimensions (15 Marks)

Prerequisite: [Historical aspects of Geometry. Fundamental concepts of Geometry: Euclid's postulates. Cartesian Frame of reference].

Transformation of rectangular coordinate axes using matrix treatment: Translation, Rotation and both. Theory of invariants using matrix method. General second degree equation. Reduction to its normal form. Classification of conics. Pair of tangents. Chord of contacts. Pole and polar, Conjugate points and conjugate lines. Diameter and conjugate diameter.

Pair of straight lines. Homogeneous second degree equation. Angle between them. Bisectors of angles of pair of lines. Condition that a second degree equation represents a pair of lines. Point of intersection. Pair of lines through the origin and the points of intersection of a line with a conic. Polar equation of a conic, tangent, normals, chord of contact.

Group D

Geometry of three dimensions (25 Marks)

Prerequisite: [Fundamental concepts. Orthogonal Cartesian Frame of reference. Coordinate system. Orthogonal projection. Direction cosines and ratios].

Transformations of rectangular coordinate axes using matrix treatment: Translation, Rotation and rigid motion. Theory of invariants using matrix method. General second degree equation involving three variables. Reduction to its normal form. Classification of surfaces.

Plane. Various form of equations of planes. Pair of planes. Angle between them. Bisectors of angles of pair of lines. Condition that a second degree equation represents a pair of planes. Point of intersection. Condition of perpendicularity and parallelism of pair of planes.

Straight line. Symmetric and non-symmetric form of straight line and conversion of one into another form. Angle between two straight lines. Distance of a point from a line. Angle between a line and a plane. Coplanarity of two lines. Shortest distance between two lines and its equation. Position of a line relative to a plane. Lines intersecting a number of lines. Tetrahedron.

Sphere, Cone, Cylinder. Condition that a general second degree equation represents these surfaces. Section of these surfaces by a plane. Circle. Generators. Sphere through a circle. Radical plane. Tangent plane. Tangent line. Normal. Enveloping cone and cylinder. Reciprocal cone.

Surfaces of revolution. Ellipsoid. Hyperboloid of one and two sheets. Elliptic Paraboloid. Hyperbolic paraboloid. Normal forms. Tangent Plane. Normal line. Generating lines and their several properties.

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3. I. N. Herstein, *Topics in Algebra,* John Wiley & Sons; 2nd Edition, 1975.

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6. U. M. Swamy & A. V. S. N. Murthy, *Algebra: Abstract and Modern*, Pearson, 2011.
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8. S. K. Mapa, *Higher Algebra (Classical),* Sarat Book House, 8th Edition, 2013.
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12. R. M. Khan, *Algebra*, New Central Book Agency Pvt. Limited, 2011.
13. Surjeet Singh, Quazi Zameeruddin, *Modern Algebra,* Vikas Publishing House, 2nd. Rev. and Enl. Ed, 1975.
14. Bhattacharyya, Jain & Nagpal, *Basic Abstract Algebra*, Cambridge University Press, second edition, 1994.
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17. B. C. Chatterjee, *Abstract Algebra*, Vol. I, Das Gupta, 1957.
18. J. G. Chakraborty & P.R.Ghosh, *Advanced Higher Algebra,* U. N. Dhur & Sons Pvt. Ltd., 11th Edition.
19. P. R. Vittal, *Analytical Geometry 2D and 3D*, Pearson Education, 2013.
20. S. L. Loney, *The Elements of Coordinate Geometry*, Reem Publications Pvt. Ltd, 2011.
21. E. H. Askwith, *A Course of Pure Geometry*, Macmillan & Co. Ltd, 1903.
22. R. J. T. Bell, *An Elementary Treatise on Co-ordinate Geometry*, Macmillan & Co. Ltd., 1963.
23. M. C. Chaki, *A Text Book of Analytical Geometry*, Calcutta Publishers, 1986.
24. R. M. Khan, *Analytical Geometry of Two and Three Dimension and Vector Analysis*, New Central Book Agency.

Paper – II

Group – A

Analysis-I (30 marks)

A brief discussion on the real number system: Field structure of R, order relation, order completeness properties of R. Arithmetic continuum, geometric continuum, Archimedean properties, interior points, open sets, limit points, closed sets, closure.

Sequence, limit of a sequence, convergence, divergence (only definitions and simple examples). Bounded functions, monotone functions. Limit of a function at a point. Continuity of a function at a point and on an interval. Properties of continuous functions over a closed and bounded interval. Uniform continuity.

Derivative of a function. Successive differentiation, Leibnitz's theorem, Rolle's theorem, mean value theorems. Intermediate value property, Darboux theorem. Taylor's theorem, and Maclaurin's theorem with Lagrange's and Cauchy's forms of remainders. Taylor's series. Expansion of elementary functions such as e^x, $\cos x$, $\sin x$, $(1+x)^n$, $\log_e(1+x)$ etc.

Envelope, asymptote, curvature. Curve tracing: Astroid, cycloid, cardioids, folium of Descartes.

Maxima, minima, concavity, convexity, singularity. Indeterminate forms. L'Hospital's theorem.

Functions of several variables (two and three variables). Continuity and differentiability. Partial derivatives. Commutativity of the orders of partial derivatives. Schwarz's theorem, Young's theorem, Euler's theorem.

Group –B

Integral Calculus (20 Marks)

Definite Integral – Definition of Definite Integral as the Limit of a Sum; Fundamental Theorem of Integral Calculus (statement only). General Properties of Definite Integral; Integration of Indefinite and Definite Integral by Successive Reduction.

Multiple Integral – Definition of Double Integral and Triple Integral as the Limit of a Sum; Evaluation of Double Integral and Triple Integral; Fubini's Theorem (statement and applications).

Applications of Integral Calculus – Quadrature and Rectification; Intrinsic Equations of Plane Curves; Evaluation of Lengths of Space Curves, Areas of Surfaces and Volumes of Solids of

Revolution. Evaluation of Centre of Gravity of some Standard Symmetric Uniform Bodies: Rod; Rectangular Area, Rectangular Parallelepiped, Circular Arc, Circular Ring and Disc, Solid and Hollow Spheres, Right Circular Cylinder and Right Circular Cone.

Group – C

Ordinary Differential Equations (Marks - 40)

Picard's existence theorem (statement only) for $\frac{dy}{dx} = f(x, y)$ with $y = y_0$ at $x = x_0$. Exact differential equations, condition of integrability. Equation of first order and first degree-exact equations and those reducible to exact form. Equations of first order higher degree-equations solvable for $p = \frac{dy}{dx}$, equations solvable for y, equation solvable for x, singular solutions, Clairaut's form. Singular solution as envelope to family of general solution to the equation.

Linear differential equations of second and higher order. Two linearly independent solutions of second order linear differential equation and Wronskian, general solution of second order linear differential equation, solution of linear differential equation of second order with constant coefficients. Particular integral for second order linear differential equation with constant coefficients for polynomial, sine, cosine, exponential function and for function as combination of them or involving them. Method of variation of parameters for P.I. of linear differential equation of second order. Homogeneous linear equation of n-th order with constant coefficients. Reduction of order of linear differential equation of second order when one solution is known.

Simultaneous linear ordinary differential equation in two dependent variables. Solution of simultaneous equations of the form dx/P = dy/Q = dz/R. Equation of the form (Paffian form) Pdx +Qdy+Rdz = 0. Necessary and sufficient condition for existence of integrals of the above.

Group – D

Partial Differential Equations (Marks - 10)

Formulation of partial differential equation, Lagrange's Linear equation. General integral and complete integral. Integral surface passing through a given curve.

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1. L.J Goldstein, David Lay, N.I.Asmar, David I. Schneider, *Calculus and Its Applications,* Pearson, New International Edition, 2014
2. W. Rudin, *Principles of Mathematical Analysis*, TMH, Third Edition , Indian Edition, 2013.
3. T. M. Apostal, *Mathematical Analysis*, Narosa Book Disributors Pvt. Ltd., 2nd Edition, 2000.
4. G. B. Folland, *Advanced Calculus*, University of Washington, Pearson, 2002.
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22. F. H. Miller, *Partial Differential Equations,* John Wiley, 1941.
23. P. Phoolan Prasad & R. Ravichandan , *Partial Differential Equations,* New Age International, 1985.
24. T. Amarnath, *Partial Differential Equation,* Narosa Publishing House, 2nd Edition, 2014.
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26. S. N. Mukhopadhyay and S. Mitra – *Mathematical Analysis – Vol-II* (U. N. Dhar & Sons. Pvt. Ltd.), 2014.

Part –II

Paper –III

Group – A

Abstract Algebra – II (20 Marks)

Normal subgroups, properties of normal subgroups, homomorphism between the two groups, isomorphism, kernel of a homomorphism, first isomorphism theorem, isomorphism of cyclic groups. Ideal of a Ring (definition, examples and simple properties).

Partial order relation, Poset, maximal and minimal elements, infimum and supremum of subsets, Lattices, definition of lattice in terms of meet and join, equivalence of two definitions.

Boolean algebra, Huntington postulates, examples, principle of duality, atom, Boolean function, conjunctive normal form, disjunctive normal form, switching circuits.

Group – B

Linear Algebra (30 Marks)

Matrices of real and complex numbers: Prerequisite [Algebra of matrices. Symmetric and skew-symmetric matrices]. Hermitian and skew-Hermitian matrices. Orthogonal matrices.

Determinants: Prerequisite [Definition, Basic properties of determinants, Minors and cofactors]. Laplaces method. Vandermonde's determinant. Symmetric and skew symmetric determinants. (No proof of theorems).

Adjoint of a square matrix. Invertible matrix, Non-singular matrix. Inverse of an orthogonal Matrix.

Elementary operations on matrices. Echelon matrix. Rank of a matrix. Determination of rank of a matrix (relevant results are to be state only). Normal forms. Elementary matrices. Statements and application of results on elementary matrices. Congruence of matrices (relevant results are to be state only), normal form under congruence, signature and index of a real symmetric matrix.

Vector space: Definitions and examples, Subspace, Union and intersection of subspaces. Linear sum of two subspaces. Linear combination, independence and dependence. Linear span. Generators of vector space. Dimension of a vector space. Finite dimensional vector space. Examples of infinite dimensional vector spaces. Replacement Theorem, Extension theorem. Extraction of basis. Complement of a subspace.

Row space and column space of a matrix. Row rank and column rank of a matrix. Equality of row rank, column rank and rank of a matrix. Linear homogeneous system of equations : Solution space. Necessary and sufficient condition for consistency of a linear non-homogeneous system of equations. Solution of system of equations (Matrix method).

Linear Transformation on Vector Spaces: Definition of Linear Transformation, Null space, range space of an Linear Transformation, Rank and Nullity, Rank-Nullity Theorem and related problems.

Diagonalization: Eigen values and eigenvectors, Statement of Cayley–Hamilton theorem and its application, Diagonalization of matrices of order 2 and 3 with application to Geometry.

Group – C
Number Theory (20 Marks)

Well ordering principle for N, Division algorithm, Principle of mathematical induction and its applications.

Primes and composite numbers, Fundamental theorem of arithmetic, greatest common divisor, relatively prime numbers, Euclid's algorithm, least common multiple.

Congruences : properties and algebra of congruences, power of congruence, Fermat's congruence, Fermat's theorem, Wilson's theorem, Euler's theorem (generalization of Fermat's theorem), Linear congruence, system of linear congruence theorem. Chinese remainder theorem.

Number of divisors of a number and their sum, least number with given number of divisors.

Eulers φ function, properties of φ function, arithmetic function, Mobius μ - function, relation between φ function and μ function.

Diophantine equations of the form ax+by = c, a, b, c integers.

Group D

Analysis-II (30 marks)

Definition of Riemann integration. Uniqueness. Darboux theory of Riemann integration. Equivalence of the two definitions. Darboux theorem (proof not required). Properties of Riemann integral. Riemann integrability of continuous function, monotone function and function having countable number of discontinuities, functions defined by the integral, their continuity and differentiability.

Fundamental theorem of integral calculus. Equivalence of Riemann integral and the anti derivative (i.e., integration as inverse process of differentiation) for continuous functions.

First and second mean value theorems of integral calculus integration by parts for Riemann integrals.

Improper integral and their convergence (for unbounded functions and for unbounded range of integration) Abel's and Dirichlet's test. Beta and Gamma functions. Evaluation of improper integrals:

$$\int_0^{\pi/2} \log \sin x dx; \int_0^{\infty} \frac{\sin x}{x} dx; \int_0^{\infty} e^{-\alpha x} \frac{\sin \beta x}{x} dx, \quad \alpha > 0;$$

and integrals dependent on them.

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3. Otto Bretscher, *Linear Algebra with Applications*, Pearson, Fifth Edition, 2012
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Paper –IV

Group – A

Vector Analysis (30 Marks)

Prerequisites: [Vector Algebra: Addition of vectors, scalar and vector products of two vectors, representation of a vector in E_3, components and resolved parts of vectors. Point of division of a line segment, signed distance of a point from a plane, vector equation of a straight line and a plane, shortest distance between two skew lines].

Product of vectors: Scalar and vector triple products, product of four vectors.

Applications of vector algebra - (i) in geometrical and trigonometrical problems (ii) to find work done by a force, moment of a force about a point and about a line (iii) to calculate volume of a tetrahedron.

Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Space curve, arc length, tangent, normal. Integration of vector-valued function of one variable. Serret-Frenet Formula

Vector-valued functions of two and three variables, gradient of scalar function, gradient vector as normal to a surface. Divergence and curl, their properties.

Evaluation of line integral of the type

$$\int_C \varphi(x,y,z)d\vec{\gamma},\ \int_C \vec{F}.d\vec{\gamma}, \int_C \vec{F}\times d\vec{\gamma}$$

Green's theorem in the plane. Gauss and Stokes theorems (Proof not required), Green's first and second identities. Evaluation of surface integrals of the type

$$\iint_S \varphi\ \overrightarrow{dS}, \iint_S \vec{F}.\overrightarrow{dS}, \iint_S \vec{n}\times\vec{F}\ \overrightarrow{dS}$$

Group-B

Dynamics of a Particle (Marks: 50)

Prerequisite: [Basic concepts of Dynamics: Motion in a straight line with uniform acceleration, Vertical motion under gravity, Momentum of a body, Newton's laws of motion, Reaction on the lift when a body is carried on a lift moving with an acceleration].

Motion of two bodies connected by a string, Composition and resolution of velocities, Relative velocity and relative acceleration.

Work, Power and Energy: Work, Power, Energy, Principle of energy, Conservative and non-conservative forces, Kinetic and potential energy, Principle of conservation of energy, Verification of principle of conservation of energy for a particle (i) moving along a straight line under a constant force, (ii) falling from rest under gravity, (iii) moving down a smooth inclined plane under gravity alone, (iv) projected in vacuum from the horizon with a constant velocity.

Impulse and Impulsive forces: Impulse, Impulsive forces, Change of momentum under impulsive forces, Principle of conservation of linear momentum, Motion of a shot and gun, Impulsive tension in a string, Principle of angular momentum.

Collision of elastic bodies: Direct and oblique impacts, Newton's experimental law of impact, Direct and oblique impacts of a smooth sphere on a fixed horizontal plane, Direct and oblique impacts of two smooth spheres, Loss of kinetic energy due to impact, Projection of a ball from a horizontal plane.

Rectilinear motion: Motion under repulsive force (i) proportional to distance (ii) inversely proportional to square of the distance, Motion under attractive force inversely proportional to square of the distance, Motion under gravitational acceleration.

Simple Harmonic Motion: Simple harmonic motion, Compounding of two simple harmonic motions of the same period, Elastic string and spiral string, Hook's law, Particle attached to a horizontal elastic string, Particle attached to a vertical elastic string, Forced vibrations, Damped harmonic oscillations, Damped forced oscillations.

Two dimensional motion: Angular velocity and angular acceleration, Relation between angular and linear velocity, Radial and transverse components of velocity and acceleration, Velocity and

acceleration components referred to rotating axes, Tangential and normal components of velocity and acceleration, Motion of a projectile under gravity (supposed constant).

Central orbits: Motion in a plane under central forces, Central orbit in polar and pedal forms, Rate of description of sectorial area, Different forms of velocity at a point in a central orbit, Apse, apse line, apsidal distance, apsidal angle, Law of force when the centre of force and the central orbit are known, Differential equation and classifications of paths under central accelerations, Stability of circular orbits, Conditions for stability of circular orbits under central force (general case).

Planetary motion: Newton's law of gravitation, Kepler's laws of planetary motion, Modification of Kepler's third law, Escape velocity, Time to describe a given arc of an orbit.

Motion in a resisting medium & Constrained motion: Motion of a heavy particle on a smooth curve in a vertical plane, Motion under gravity with resistance proportional to some integral power of velocity, Motion of a projectile in a resisting mediumTerminal velocity, Motion of a particle in a plane under different laws of resistance, Motion on a smooth cycloid in a vertical plane, Motion of a particle along a rough curve (circle, cycloid).

Group C

Tensor Calculus (20 Marks)

Historical study of tensor. Concept of E^n. Tensor as a generalization of vector in E^2, E^3 and E^n. Einstein's Summation convention. Kronecker delta.

Algebra of tensor: Invariant. Contravariant and covariant vectors. Contravariant, covariant and mixed tensors. Symmetric and skew-symmetric tensors. Addition, subtraction and scalar multiplication of tensors. Outer product, inner product and contraction. Quotient law.

Calculus of tensor: Riemannian space. Line element. Metric tensor. Reciprocal metric tensor. Raising and lowering of indices. Associated tensor. Magnitude of vector. Angle between two vectors. Christoffel symbols of different kinds and laws of transformations. Covariant differentiation. Gradient, divergence, curl and Laplacian. Ricci's theorem. Riemann-Christoffel curvature tensor. Ricci tensor. Scalar curvature. Einstein's space (Definition only).

References:

1. A. A. Shaikh & S. K. Jana, *Vector Analysis with Applications*, Narosa Publishing House Pvt. Ltd., New Delhi, 2009.
2. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd., 1965.
3. L. Brand, *Vector Analysis*, Dover Publications Inc., 2006.
4. Shanti Narayan**,** *A Text Book of Vector Analysis,* S.Chand publishing, 19th Edition, 2013.
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6. C. E. Weatherburn, *Elementary Vector Analysis*: *With Application to Geometry and Physics*, Bell, 1921.
7. E. W. Hobson, *A Treatise of Plane Trigonometry*, Cambridge, University Press, 3rd Edition, 1911.
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14. N. Dutta and R. N. Jana, *Dynamics of a Particle*, Shreedhar Prakashani, 4th Edition, 2000.
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19. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 2003.

Part –III

Paper –V

Group – A

Analysis – III (50 marks)

Sequence of real numbers. Notion of convergence and limit. Monotone sequences subsequences and their convergence, upper and lower limits of a sequence, algebra of limit superior and limit inferior. Cauchy's general principle of convergence. Bolzano-Weierstrass theorem, Heine-Borel theorem.

Series of non negative terms. Test for convergence: Comparison test, Ratio test, Cauchy's root test, Raabe's test, Logarithmic test, Gauss's test, Cauchy's condensation test. Alternating series, Leibnitz's test.

Series of arbitrary numerical terms. Absolutely and conditionally convergent series, Riemann's rearrangement theorem (Proof not required)

Sequences and series of functions and their convergence. Uniform convergence. Cauchy's criterion of uniform convergence. Continuity of a limit function of a sequence of continuous functions. Continuity of the sum function of a uniformly convergent series of continuous functions. Term-by-term differentiation and integration of a uniformly convergent series of functions.

Fourier series of a function. Dirichlet's condition (statement only). Uniformly convergent trigonometric series as a Fourier series. Riemann-Lebesgue theorem on Fourier series. Series of odd and even functions. Convergence of Fourier series of piece-wise monotone functions (Proof not required)

Functions of several variables (two and three variables): Theory of maxima and minima, Lagrange's method of multiplier. Jacobian, Implicit function theorem (Proof not required). Inverse function theorem (statement only). Change of variables of multiple integrals.

Differentiation and integrals under the sign of integration. Integral as a function of parameter. Change of order of integration for repeated integrals.

Group-B

Complex Analysis (20 Marks)

Introduction of complex numbers as ordered pair of real numbers (a, b) and their representation as $a + ib$, the complex plane $\mathbb{C}$ and its basic geometric and topological aspects, continuity, differentiability of complex valued functions, Cauchy-Riemann (C-R) equations, analytic functions.

Power series, radius of convergence and Cauchy-Handamard theorem, infinite differentiability of sum function of power series, introduction of exp (z), cos$z$, sin$z$, log$z$ and its branch-their elementary properties.

Extended complex plane $\mathbb{C}_\infty$, stereographic projection and spherical representation of $\mathbb{C}_\infty$.Bilinear transformations: The group of Mobius transformation and its generators-the inversion, dilations; fixed point and uniqueness of a Mobius transformation by its action at three distinct points; cross ratio, cross ratio and circle preserving property of Mobius transformation; orientation principle and construction of bijective analytic functions from one side of a circle onto one side of another circle in $\mathbb{C}_\infty$.

Group-C

Metric Spaces (30 Marks)

Definition of Metric spaces, examples including the standard ones such as discrete metric space, the real line $\mathbb{R}$, the complex plane $\mathbb{C}$, Euclidian spaces $\mathbb{R}^n$, unitary spaces $\mathbb{C}^n$, $C[a,b]$ (with sup metric and integral metric), $l^p, 1 \le p < \infty$.

Open ball, closed ball, metric topology, distance between a point and a set, distance between two sets, boundedness of a set, properties of open and closed sets, limit point, interior point, closure, interior, boundary of subsets and relation between them; dense subsets, nowhere dense subsets, basis, separable space, Lindel$\ddot{\text{O}}$f space, second countable space and relation between them; Hausdorff property, Cauchy sequence, Convergence of sequences, completeness and Cantor Intersection theorem.

Continuous functions and their basic properties, algebra of real/ complex valued continuous

functions, uniformly continuous functions, uniform continuity of the distance function.

Open covering and compactness, compactness and finite intersection property (FIP) of closed sets, closed subsets and compactness, continuity and compactness; relation between continuity, compactness and uniform continuity; equivalence of compactness, sequential and B-W compactness; boundedness, total boundedness and relation between them; relation between total boundedness, completeness and compactness; distance between disjoint closed sets one of which being compact, Heine Borel theorem concerning compact sets in R^n.

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Paper – VI

Group –A

Elements of Continuum Mechanics (10 Marks)

Idea of continuum, idea of strain and stress at a point in a continuum, stress vector, stress matrix, ideal fluid, viscous fluid.

Group – B

Classical Dynamics, Dynamics of a system of Particles and rigid body (40 Marks)

Physical foundation of classical dynamics: Interpretation of Newton's laws of motion – body force and surface force with examples, inertial frames, law of superposition, closed systems, concepts of absolute time, concepts of absolute space, concepts of absolute simultaneity of events; Galilean transformation – form invariance of Newton's laws under Galilean transformation, limitations of direct applications of Newton's laws in solving problems of mechanics.

Dynamics of a system of particles: Basic concepts, Centroid, linear momentum, angular momentum, kinetic energy, potential energy, work, power, conservative system of forces; Use of centroid – motion relative to the centroid, angular momentum and kinetic energy relative to the centroid; Conservation principles – linear momentum, angular momentum, total energy; Constraints – basic concepts with examples, D'Alembert Principle.

Introduction to rigid body dynamics: Moments and product of inertia – basic concepts, radius of gyration, parallel and perpendicular axis theorems, a few examples (rod, rectangular plate, circular plate, elliptic plate, sphere, cone, rectangular parallelepiped, cylinder, ellipsoid of revolution etc.); Motion about a point and about fixed axes – angular momentum, inertia matrix, principal axes, principal moments of inertia, kinetic energy, momental ellipsoid, equimomental surface, reaction of the axis of rotation, impulsive forces; General motion of rigid body – translational and rotational motion, kinetic energy and angular momentum (translational and rotational); Two-dimensional motion of rigid body - equation of motion, kinetic energy, angular momentum, problems illustrating laws of motion [motion of a uniform sphere (solid and hollow) along a perfectly rough plane, motion of a uniform heavy circular cylinder (solid and hollow) along a

perfectly rough inclined plane, motion of a rod when released from a vertical position with one end resting upon a perfectly rough table or smooth table, motion of a uniform heavy solid sphere along an imperfectly rough inclined plane, motion of a uniform circular disc, projected with its plane vertical along an imperfectly rough horizontal plane with a velocity of translation and angular velocity about the centre].

Group – C

Statics (20 Marks)

Prerequisite: [Basic concepts – concurrent forces, parallel forces, moment of a force, couple, resultant of a force and a couple].

Forces in three-dimension – reduction to force and couple, Pointsot's central axis, wrench, pitch, screw, conditions of equilibrium, invariants; Virtual work – concept of virtual displacement, principle of virtual work, simple examples; Stability of equilibrium – stable and unstable equilibrium, energy test of stability, determination of positions of equilibrium, stability of a heavy body resting on a fixed body with smooth surfaces, simple examples; Equilibrium of flexible string – general equations of equilibrium of a uniform flexible string under the action of given coplanar forces, common catenary, parabolic chain, suspension bridge, catenary of uniform strength.

Group – D

Hydrostatics (30 Marks)

Basic concepts – fluid pressure and its elementary properties (such as in equilibrium it is same in every direction), density, specific gravity, compressible and incompressible fluid, homogeneous and non-homogeneous fluid; Equilibrium of fluid in a given field of force – equation of pressure, conditions of equilibrium, pressure gradient, equipressure surface, equilibrium of fluid rotating uniformly about an axis; Pressure in a heavy homogeneous liquid – thrust on a plane surface, centre of pressure, determining the position of the centre of pressure, effects on increasing depth, thrust on a curved surface, buoyancy, Archimedes principle, resultant thrust, Equilibrium of floating bodies – conditions of equilibrium of a freely floating body, body floating under constraints, equilibrium of fluids revolving uniformly about an axis, stability of equilibrium, metacentre, conditions of stability; Gases – relation among pressure, volume and temperature, Boyle's law, Charle's law, ideal gas, isothermal and adiabatic changes, heat capacities, internal

energy of a gas, reversible change, equilibrium of an isothermal atmosphere, convective equilibrium, total energy at rest.

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Paper-VII

Group-A

Mathematical Probability (40 Marks)

Prerequisite: [Concept of mathematical probility, addition and multiplication theorem of probability. Independent event, total probability, Bayes' theorem, Bernoulli trials, Binomial distribution].

Generalised addition and multiplication rule of probability continuity theory, Boole's inequality, Bonferroni's inequality; Poisson trials and Poisson law of probability, Multinomial law; Random variables, Discrete and continuous distribution functions: Poisson, Geometric, Negative Binomial, exponential, Hypergeometric, Uniforn, Normal, Gamma, Beta, Cauchy distributions,

Transformation of random variables; Discrete and continuous distribution in two dimension, Marginal distribution, Bivariate Uniform distribution, Bivariate Normal distribution, Transformation of two dimensional random variables, Conditional distribution, Mathematical expectation in one and two variables, Moments, Measures of skewness and kurtosis, Moment generating function, Characteristic function, Uniqueness of characteristic function (statement only) Conditional expectation, covariance, co-relation coefficient, Regression curves, χ^2 and t-distribution, convergence in probability, convergence in law, Tchebycheff's inequality, Bernoulli's limit theorem, Law of large numbers, Concept of asymptotically normal distribution, De-Moivre-Laplace limit theorem, Central limit theorem in case of equal components.

Group -B

Statistics (20 Marks)

Method of least square, curve fitting (straight line, parabola and exponential curves).

Sampling theory, simple random sampling, sampling distribution of the statistic; χ^2 , t and F-distribution of the statistic.

Theory of estimation, point estimation, unbiasedness, minimum variance, consistency, efficiency, sufficiently, maximum likelihood method; Interval estimation –confidence interval, approximate confidence interval. Testing of hypothesis, Neyman-Pearson lemma, Likelihood ratio testing, application to Normal(m, σ)-population, Pearsonian χ^2-test for goodness of fit. Theory of errors.

Group – C

Operations Research (Marks - 40)

Prerequisite: [General introduction to optimization problem, Definition of L.P.P., Mathematical formulation of the problem, Canonical & Standard form of L.P.P., Basic solutions, feasible, basic feasible & optimal solutions].

Reduction of a feasible solution to basic feasible solution.

Hyperplanes, Convex sets and their properties, Convex functions, Extreme points, Convex feasible region, Convex polyhedron, Polytope, Supporting hyperplane, Separating hyperplane.

Fundamental theorem of L.P.P., Replacement of a basis vector, Improved basic feasible solutions, Unbounded solution, Condition of optimality, Simplex method, Simplex algorithm, Artificial

variable technique (Big M method, Two phase method), Inversion of a matrix by Simplex method, Solution of simultaneous equations by Simplex method.

Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method, Dual simplex method and algorithm.

Transportation Problem (T.P.): Mathematical formulation, Existence of feasible solution, Loops and their properties, Initial basic feasible solutions (different methods, like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Optimal solutions, Degeneracy in T.P., Unbalanced T.P., Special cases in T.P.

Assignment Problem (A.P.): Mathematical formulation, Solution methods of A.P., Hungerian method, Restrictions on assignments, maximization problem, unbalanced assignment problem, Traveling salesman (salesperson) problem.

Theory of Games: Introduction, Two person zero-sum games, Minimax and Maximin priciples, Minimax and Saddle point theorems, Pure and Mixed Strategies games without saddle points, Minimax (Maximin) criterion, Dominance rules, Solution methods of games without saddle point : Algebraic method, Graphical method and Linear Programming method, Symmetric game.

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Paper – VIII

Group A

Numerical Analysis (35 Marks)

Approximation of numbers, significant digits, Loss of significance, Algebraic manipulation for avoiding loss of significance.

Errors: Absolute, Relative and Percentage errors; Inherent errors in numerical methods.

Polynomial Interpolations: Existence and uniqueness of interpolating polynomials, error in interpolation, Lagrange's interpolating formula, Newton's divided difference interpolating formula, properties of divided differences, forward and backward difference operators and their relations, Newton's forward and backward difference interpolation formulae.

Central difference and averaging operators, central interpolation formulae: Statement of Gauss, Stirling and Bessel's formulae and their applications. Concept of piece-wise polynomial interpolation, Idea of Inverse interpolation.

Numerical solution of non-linear equations:

Solution of algebraic and transcendental equations (real roots only): (i) Method of Bisection, (ii) Regula Falsi Method (iii) Secant Method (iv) Newton – Raphson Method (v) Fixed point iteration method. Convergences and rate of convergence of these methods.

Solution of a system of linear algebraic equation:

Gauss' Elimination and Gauss Jordan methods, Pivoting methods, Jacobi and Gauss-Seidel methods with convergence criteria.

Numerical Integration: Concept of numerical quadrature, Newton-Cotes' formula trapezoidal rule, Simpson's one-third rule, Geometrical interpretation of the methods, Degree of precision.

Solution of first-order ordinary differential equation: Picard's method, Euler's method, Modified Euler's method, Error estimate and convergence of Euler's method, Taylor's method, Runge-Kutta's method of second and fourth orders (derivation of second order formula only)

Group-B

Computer Programming (Marks – 15)

Computer Language: Concept of programming languages, Machine language, Assembly language, High-level language, Interpreter, Compiler, Source and Object programs.

Number Systems: Binary, decimal, octal and hexadecimal number systems and their conversions.

Programming Language in C: C-Character set, Keywords, Basic data types, Numeric constants and variables operators, Expressions, Assignment statements, I/0 – statements.

Control Statements: Decision making and Looping statements in C, break continue and goto statements, Example of simple programs.

Subscripted variables: Concept of array variables in programming language, Rules for one dimensional subscripted variable in C, Simple programs.

Sub-program: Concept of sub-program, purpose of sub-program, Definition of function and function prototype, Simple programs.

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Paper-IX

Computer Aided Numerical Methods: Practical (using C programming) (Marks: 50)

Sessional (Algorithm, Flowchart and Program with output) : 10 marks

Problem – I: 25 marks (Algorithm-5, Flowchart-5, Program-10, Result-5)

Problem - II: 10 Marks

(Program – 5, Result – 5)

Viva-voce: 5 marks

Problem-I: 1. Interpolation (taking at least six points) by

(a) Lagrange's interpolation formula,
(b) Newton's Forward Difference formula

Problem-I: 2. Solution of a first-order ordinary differential equation by

(a) Modified Euler's method,
(b) Fourth-order Runge-Kutta method

Problem-I: 3. Solution of system of linear equations by

(a) Gauss elimination method (excluding pivotal condensation)

Problem-II: 1. Finding a real root of an equation by

(a) Fixed point iteration method,

(b) Newton-Raphson's method

Problem-II: 2. Integration (taking at least 10 sub-intervals) by

(a) Trapezoidal rule,
(b) Simpson's 1/3 rd rule

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