

**B.A. /B.Sc. - Part I**  
**(Mathematics)**  
**Paper I: Algebra and Trigonometry**

**UNIT 1:** Symmetric, Skew-symmetric, Hermitian & Skew-Hermitian matrices, Elementary transformations on matrices and elementary matrices, inverse of a matrix, Linear independence of rows and columns of the matrices, Row rank, Column rank and rank of a matrix, equivalence of row and column ranks, Orthogonal, unitary and similar matrices, congruence of matrices, Involutory, Idempotent & Nilpotent matrices.

**UNIT 2:** Application of matrices to solve a system of linear equations (both homogeneous and non-homogeneous systems), Theorems on consistency of system of linear equations, Eigen values and Eigen vectors & Characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix.

**UNIT 3:** Properties of integers, Division algorithm, Euclidean algorithm, Fundamental theorem of arithmetic, Congruence modulo  $n$ , Definition of a group with examples and simple properties, Subgroups, Generation of groups, Cyclic groups, Coset decomposition, Lagrange's theorem, Euler's & Fermat's theorem.

**UNIT 4:** Group homomorphism, Isomorphism, Normal subgroups, Quotient groups, The Fundamental theorem of homomorphism. Permutation groups, Even and odd permutations, the alternating groups  $A_n$ , Cayley's theorem.

**UNIT 5:** Direct and inverse circular and hyperbolic functions, Logarithm of complex quantities, Expansion of trigonometrical functions, Gregory's series, Summation of series.

**Books Recommended:**

- I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd.
- K. B. Dutta: Matrix and Linear Algebra, Prentice Hall.
- Ram Ji Lal: Algebra, Vol. 1, Shail Publication, Allahabad.
- P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul: First course in Linear Algebra.
- R. S. Mishra & N. N. Bhattacharya: Modern Algebra, Pothishala Pvt. Ltd., Allahabad.

**B.A. /B.Sc. - Part I**  
**(Mathematics)**  
**Paper II: Calculus**

**UNIT 1:**  $\epsilon$ - $\delta$  definition of limit of a function, Properties of limits, Continuous functions and classification of discontinuities, Differentiability and its basic examples, Successive differentiation, Leibnitz's theorem.

**UNIT 2:** Maclaurin's and Taylor series expansion, Asymptotes, Curvature, Partial differentiation, Tests for concavity and convexity, Points of inflection, Multiple points, Tracing of curves in Cartesian and polar coordinates.

**UNIT 3:** Quadrature, Rectification, Volumes and surfaces of solids of revolution.

**UNIT 4:** Degree and order of a differential equation, Initial and Boundary conditions and problems, Equation of first order and first degree, Equations in which variables are separable, Homogeneous equations, linear equation and equations reducible to linear forms. Exact differential equations. First order & higher degree differential equations solvable for  $x, y$  & Clairaut's form and singular solution.

**UNIT 5:** Orthogonal Trajectories, Linear differential equations with constant coefficients.

**References:**

- Gorakh Prasad: Differential Calculus.
- Gorakh Prasad: Integral Calculus.
- P. K. Jain & S. K. Kaushik: An introduction to real analysis.
- Mathematical Analysis: Shanti Narain.
- Ordinary Differential equations with integration: R. S. Sengar (Prayag-Publi.).

**B.A. /B.Sc. - Part I  
(Mathematics)**

**Paper III: Vector Analysis & Geometry**

**UNIT 1:** Vector Differentiation, Gradient, Divergence & Curl, Vector Integration.

**UNIT 2:** Theorems of Gauss, Green and Stokes, and Problems based on them.

**UNIT 3:** Confocal conics, conics treated by polar coordinates.

**UNIT 4:** Plane, The straight lines and Sphere.

**UNIT 5:** Cone & Cylinder.

**Books Recommended:**

- N. Saran & S. N. Nigam: Introduction to vector analysis.
- Shanti Narain: A Text book of Vector Calculus, S. Chand & Co., New Delhi.
- N. Saran & R. S. Gupta: Analytical geometry of three dimensions.
- H. D. Pandey: Analytical Geometry & Vectors.
- R. J. T. Bell: Elementary Treatise on Co-ordinate geometry of three dimensions.

## **B.A./B.Sc.-Part II (Mathematics)**

### **Paper-I: Advanced Calculus**

**UNIT 1:** Bounded sets of real numbers, Supremum, Infimum, existence of supremum and infimum of bounded sets, Archimedean property, Sequences, Theorems on limits of sequences, Bounded and monotonic sequences, Cauchy's convergence criterion.

**UNIT 2:** Series of non-negative terms, comparison tests, Cauchy's integral test, Ratio test, Raabe's test, Logarithmic, De-Morgan and Bertrand's test. Alternating series, Leibnitz theorem, Absolute and conditional convergence.

**UNIT 3:** Continuity, Sequential continuity, Properties of continuous functions, Uniform continuity, Chain rule of differentiability, Rolle's theorem, Mean value theorems and their geometrical interpretation, Darboux's Intermediate value theorems on derivatives. Taylor's theorem with various form of remainders.

**UNIT 4:** Limit and continuity of function of two variables, Partial differentiation, change of variables, interchange of variables, Euler's theorem on homogeneous functions, Jacobians, Envelopes and Evolutes, Maxima, minima and saddle points of function of two variables, Lagrange's multiplier method.

**UNIT 5:** Beta and Gamma functions, Double and Triple integrals, Dirichlet's integrals, Change of orders of integration in double integrals.

#### **Books Recommended:**

- Gorakh Prasad: *Differential Calculus*, Pothishalas Pvt Ltd., Allahabad.
- Gorakh Prasad: *Integral Calculus*, Pothishalas Pvt Ltd., Allahabad.
- D. Soma Sundaram & B. Chaudhary: *A first course of Mathematical Analysis*,
- Shanti Narayan: *A course of Mathematical Analysis*, S. Chand & Co. New Delhi.
- S. C. Malik and Savita Arora: *Mathematical Analysis*, New Age International (P) Ltd. 1996.
- D. E. Stanaitis: *an introduction to sequences, series and improper integrals*.

**B.A./B.Sc.-Part II  
(Mathematics)**

**Paper-II: Differential Equation**

**UNIT 1:** Linear equation of second order, variation of parameters, Homogenous and exact equations.

**UNIT 2:** Simultaneous equations, Ricatti equation, Total differential equations.

**UNIT 3:** Formation of partial differential equations, Partial differential equations of the first order, Cauchy's problem of first order differential equation, Lagrange's solution, Some special types of equations which can be solved easily by methods other than the general method.

**UNIT 4:** Charpit's general method of solution, Jacobi's method and Cauchy's method of characteristics.

**UNIT 5:** Partial differential equations of second and higher orders, classification of linear partial differential equation of second order, Homogeneous and non-homogeneous equations with constant coefficients, PDE reducible to equations with constant coefficients, Monge's method.

**Books Recommended:**

- Piaggio: An elementary treatise on differential equations and their applications.
- A. R. Forsyth: *A Treatise on Differential Equation*, Macmillon & Co. Ltd. London.
- I. N. Sneddon: *Elements of Partial Differential Equations*, McGraw Hill Book & Co., 1988.
- N. M. Kapoor: A text book of differential equations
- T. Amarnath: An elementary course in PDE.

**B.A./B.Sc.-Part II**  
**(Mathematics)**  
**Paper-III: Mechanics**

**UNIT 1:** Virtual work, Catenary.

**UNIT 2:** Forces in three dimensions, Poincot's central axis, Wrenches, Null lines and null planes.

**UNIT 3:** Stable and unstable equilibrium, Rotation of vector in two dimensions, Radial and transverse velocities and accelerations, Normal and tangential velocities and accelerations, Angular velocities and accelerations.

**UNIT 4:** Simple harmonic motion, Elastic strings (Horizontal and vertical), Motion in resisting medium, Motion of a particle of varying mass, Motion on smooth curves in vertical planes.

**UNIT 5:** Central orbits, Kepler's laws of motion, Motion under inverse square law, Motion of a particle in three dimension, Acceleration in terms of different coordinate systems.

**References:**

- M. Ray: Dynamics.
- R. S. Verma: Statics.
- S. L. Loney: Dynamics of a particle of rigid body.
- S. L. Loney: Statics.

## **B.A./B.Sc.-Part III (Mathematics)**

### **Paper-I: Real and Complex Analysis**

**UNIT 1:** Riemann integral, Integrability of continuous and monotonic functions on bounded intervals, Fundamental theorem of integral calculus, Mean value theorems of integral calculus. Fourier series, Fourier expansion of piecewise monotonic functions.

**UNIT 2:** Improper integrals and their convergence, Comparison test, Abel's test and Dirichlet's test, Series of arbitrary terms, convergence, divergence and oscillations. Abel's and Dirichlet's test, Multiplication of series, Double series.

**UNIT 3:** Partial derivation and Differentiability of real valued functions of two variables. Schwarz's and Young's theorem. Complex numbers as ordered pairs, Geometric representation of complex numbers, Stereographic projection, continuity and differentiability of complex valued functions. Cauchy-Riemann equations & Harmonic functions.

**UNIT 4:** Elementary functions, Mappings by elementary functions, Mobius transformations, fixed points, Cross ratios, Inverse points and critical mappings, conformal mappings. Cauchy's theorem, Cauchy's Integral formula, higher order derivatives.

**UNIT 5:** Morera's theorem, Cauchy's inequality, Liouville's theorem, Taylor's theorem, Laurent's theorem, fundamental theorem of algebra, Zeros and singularity. Cauchy's residue theorem & contour integration.

#### **Books Recommended:**

- Shanti Nrayan: A course of Mathematical Analysis, S. Chand & Co., New Delhi.
- T. M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
- D. Som Sundaram & B. Chaudhary: A First course in Analysis
- P. K. Jain & S. K. Kaushik: An introduction to Real Analysis, S. Chand & Co. New Delhi, 2000.
- R. R. Goldberg: Real Analysis
- Ahlfors: Complex Analysis
- R. V. Churchill & J. V. Brown: Complex Variables & Applications.

**B.A./B.Sc.-Part III  
(Mathematics)  
Paper-II: Abstract Algebra**

**UNIT 1:** The isomorphism theorems for groups. Automorphisms and inner automorphisms. Automorphism groups and their computations. Conjugacy relation. Normalizer and centralizer. Group actions, stabilizers and orbits.

**UNIT 2:** The class equation of a finite group using group action, centre of groups of prime power orders, Abelianizing a group and its universal properties. Sylow's theorems and Sylow  $p$ -subgroups. Rings, Sub-rings and integral domains, Fields, characteristic of a ring. Ring homomorphisms. Ideals and quotient rings. Field of quotient of an integral domain.

**UNIT 3:** Euclidean rings, Principal ideal domains, Polynomial rings, Division algorithm in  $F[x]$ ,  $F[x]$  is a PID, Polynomial over rational field, The Eisenstein irreducibility criteria, Euclidean ring  $Z[i]$ , Unique Factorization Domain (UFD),  $R$  is UFD implies  $R[x]$  is UFD.

**UNIT 4:** Definition and examples of vector spaces, Subspaces, Direct sum of subspaces, Linear dependence and Independence and their basic properties. Basis. Finite dimensional vector spaces. Existence theorem for basis. Invariance of the number of elements of a basis set. Dimension of sums of subspaces. Quotient spaces and its dimension. Linear transformation and their representation as matrices. The algebra of linear transformation. Rank-Nullity theorem. Change of basis.

**UNIT 5:** Dual spaces, Bidual spaces and Natural isomorphism. Adjoint of linear transformation. Eigen values and eigen vectors of L.T., Diagonalization, Annihilator of a subspace. Inner product spaces. Cauchy Schwarz inequality, orthogonal complements, orthogonal sets and bases. Bessel's inequality, Gram Schmidt orthogonalization process.

**Books Recommended:**

- I. N. Herstein: Topics in Algebra
- Ram Ji Lal: Algebra, Vol. 1 & 2, Shail Publication, Allahabad.
- P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul: Basic Abstract Algebra.
- S. Kumaresan: Linear Algebra
- Vivek Sahai & Vikas Bist: Algebra
- V. K. Khanna & S. K. Bhambri: Abstract Algebra



**B.A./B.Sc.-Part III  
(Mathematics)**

**Paper-III: Metric Spaces & Laplace Transformation  
and Calculus of Variation**

**UNIT 1:** Definition and examples of metric spaces, Neighbourhoods, Limit points, Interior points, open sets and closed sets, Closure and interiors, Boundary points, subspace of a metric space, Cauchy sequences, Completeness, Completeness of  $L^p$  spaces for  $1 \leq p \leq \infty$ , Cantor's intersection theorem, Contraction Principle.

**UNIT 2:** Construction of real numbers as the completion of incomplete metric spaces of rationals. Real numbers as a complete ordered field. Dense subsets, Baire category theorem. Separable, second countable and first countable spaces. Continuous functions, uniform continuity, Isometry and homeomorphism, Equivalent metrics.

**UNIT 3:** Compactness, sequential compactness. Totally bounded spaces, Finite intersection property, continuous functions and compact sets, Connectedness, Components, Continuous functions and connected sets.

**UNIT 4:** Laplace Transformation- Linearity of Laplace Transformations, Existence theorem for Laplace Transforms, Laplace Transforms of derivatives and integrals. Shifting theorems. Differentiation and integration of transforms. Convolution theorem, Solution of differential equations using the Laplace Transformation. Fourier transform and convolution theorems.

**UNIT 5:** Variational problems with fixed boundaries, Euler's equations for functional containing first order and higher order total derivatives, Functional containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinate transformation.

**Books Recommended:**

- E. T. Copson: Metric Spaces
- P.K. Jain & Khalil Ahmed: Metric Spaces
- T. M. Apostol: Mathematical Analysis
- Walter Rudin: Analysis
- Erwin Kreyszig: Advanced Engineering Mathematics
- A.S. Gupta: Calculus of Variations

**B.A./B.Sc.-Part III  
(Mathematics)**

**Paper-IV: Differential Geometry**

**UNIT 1:** Definition of a tensor, Transformation of coordinates, Contravariant and covariant tensors, contraction, Inner product, associated tensors, reciprocal tensors.

**UNIT 2:** Christoffel's symbols, Covariant differentiation, Gradient, divergence and curl in tensor notation, curvature tensor, Ricci tensor.

**UNIT 3:** Local theory of space curve, tangents, principal normal and bi-normal, curvature & torsion of a space curve, Serret-Frenet apparatus, contact between curve and surfaces, involutes and evolutes, Fundamental existence theorem for space curve.

**UNIT 4:** Theory of surfaces, Definition of a surfaces, surface of revolutions, metric, Direction coefficients, families of curve, Isometric correspondence.

**UNIT 5:** Intrinsic properties of surfaces, first & second fundamental forms, Gaussian curvature, Principal direction and principal curvature, Conjugates direction, asymptotic directions, asymptotic lines, Geodesics, Fundamental equation of surface theory.

**Books Recommended:**

- C E. Weatherburn: Differential Geometry of three dimensions
- C E. Weatherburn: Intro. To Riemannian Geometry and Tensor Calculus.
- L. P. Eisenhart: Differential Geometry
- M. Docarmo: Differential Geometry of curves and surfaces.