**Department of Mathematics**
**Faculty of Natural Science, Jamia Millia Islamia, New Delhi-25**
**Structure of B. A./ B. Sc. (Hons.) Mathematics (Core Courses)**

**Semester – I**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-1.1 | Calculus | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-1.2 | Algebra | 4 | 4 | 25 | 75 | 100 |

**Semester – II**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-2.1 | Differential Equations – I | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-2.2 | Operations Research and Linear Programming | 4 | 4 | 25 | 75 | 100 |

**Semester – III**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-3.1 | Analysis – I | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-3.2 | Group Theory | 4 | 4 | 25 | 75 | 100 |
| 3 | BHM-3.3 | Numerical Methods | 4 | 4 | 25 | 75 | 100 |

**Semester – IV**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-4.1 | Analysis – II | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-4.2 | Differential Equations – II | 4 | 4 | 25 | 75 | 100 |
| 3 | BHM-4.3 | Ring Theory | 4 | 4 | 25 | 75 | 100 |

**Semester – V**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-5.1 | Functions of Several Variables | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-5.2 | Metric Spaces | 4 | 4 | 25 | 75 | 100 |
| 3 | BHM-5.3 | Linear Algebra | 4 | 4 | 25 | 75 | 100 |

**Semester – VI**

| S. No. | Code | Title of paper | Unit | Credit | Internal Assessment | Semester Examination | Total Marks |
|---|---|---|---|---|---|---|---|
| 1 | BHM-6.1 | Mechanics | 4 | 4 | 25 | 75 | 100 |
| 2 | BHM-6.2 | Geometry of Curves and Surfaces | 4 | 4 | 25 | 75 | 100 |
| 3 | BHM-6.3 | Complex Analysis | 4 | 4 | 25 | 75 | 100 |

## B. A./ B. Sc. (Hons.) Mathematics, Semester – I

| BHM-1.1 | Calculus | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs. | | 4 | 4 | 4 |

**Unit-I** Limit and Continuity by $\varepsilon - \delta$ approach, Differentiability, Successive differentiation, Leibnitz Theorem, Rolle's Theorem, Mean Value Theorems, Taylor and Maclaurin series.

**Unit-II** Indeterminate forms, Curvature, Cartesian, Polar and parametric formulae for radius of curvature, Partial derivatives, Euler's theorem on homogeneous functions.

**Unit-III** Asymptotes, Test of concavity and convexity, Points of Inflexion, Multiple points, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves.

**Unit-IV** Derivations and illustrations of reduction formulae of the various types. Volumes by slicing; disks and washers methods, volumes by cylindrical shells, parametric equations, arc length, arc length of parametric curves, surfaces of solids of revolution

**Books Recommended**


1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P.Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. Gorakh Prasad, Differential Calculus, Pothishala Pvt. Ltd.
5. Khalil Ahmad, Text Book of Calculus, World Education Publishers, 2012.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – I

| BHM-1.2 | Algebra | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs. | | 4 | 4 | 4 |

**Unit-I** Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principle of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

**Unit-II** Systems of linear equations, row reduction and echelon forms, vector equations, Theorem on consistencies of a system of linear equations, the matrix equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence.

**Unit-III** Inverse of a matrix by transformation, normal form, characterizations of invertible matrices, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley Hamilton Theorem and its application.

**Unit-IV** De Moivre's theorem and its application. Circular and Hyperbolic functions. Inverse circular and hyperbolic functions. Expansion of trigonometric functions in terms of power and multiple. Separation of real and imaginary parts of various functions. Summation of series including C+iS method.

**Books Recommended:**


1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. Ushri Dutta, A. S. Muktibodh and S. D. Mohagaonkar: Algebra and Trigonometry, PHI,2006.
4. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. J. Finkbecner: Matrix Theory.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – II

| BHM-2.1 | Differential Equations – I | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs. | | 4 | 4 | 4 |

**Unit-I** Formulation of differential equations, Order and degree of a differential equation, equations of first order and first degree, solutions of equations in which variables are separable, Homogeneous equations, Linear equations and Bernoulli equations, Exact differential equations, integrating factors, Change of variables.

**Unit-II** Equations of the first order and higher degree, Equations solvable for *p, y* and *x*, Clairaut equation, Lagrange's equation, Trajectories.

**Unit-III** Linear differential equations with constant coefficient, Complementary function and particular integral. Particular integral of the forms $e^{ax}$, $Sinax$, $Cosax$, $x^m$ and $e^{ax}V$, Homogeneous linear equations.

**Unit-IV** Linear differential equations of second order, Complete solution in terms of known integral belonging to the complementary function, Normal form, Change of independent variable, Method of undetermined coefficients, Method of variation of parameters, Simultaneous equations with constant coefficients, Simultaneous equations of form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$.

**Books Recommended:**


1. C. H. Edwards and D. E. Penny, *Differential Equations and Boundary Value Problems: Computing and Modelling*, Pearson education, India 2005.
2. Dennis G. Zill, *A first course in differential equations*,
3. S. L. Ross: *Differential equations*, John Wiley and Sons, 2004.
4. Zafar Ahsan: *Text Book of Differential Equations and their Applications*, Prentice Hall of India.
5. Khalil Ahmad: *Text Book of Differential Equations*, World Education Publishers, 2012.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – II

| BHM-2.2 | Operations Research and Linear Programming | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs. | | 4 | 4 | 4 |

**Unit-I** Operations Research (OR) and its Scope, Modelling in OR, Scientific Method in Operations Research, Linear Programming: Definition, mathematical formulation, standard form. Solution – feasible, basic feasible, optimal, infeasible, multiple, redundancy, degeneracy, Solution of LP Problems - Graphical Method, Simplex Method.

**Unit-II** Duality in LP, Dual Simplex Method, Economic interpretation of Dual, Transportation Problem, Basic feasible solution using different methods (North-West corner, Least Cost, Vogel's Approximation Method), Optimality Methods, Unbalanced transportation problem, Degeneracy in transportation problems, Assignment Problem, Hungarian Method for Assignment Problem.

**Unit-III** Elementary inventory models, Replacement models, Group replacement problem, Sequencing theory, *m* machines and *n* jobs problem, Graphical method for sequence problem.

**Unit-IV** Game Theory, pure and mixed strategies, Saddle point, Two-Persons-Zero-Sum Game, Game with mixed strategies, Dominance rule, Graphical Method, Inter - relation between the theory of games and linear programming, Solution of game using Simplex method.

**Books Recommended:**


1. A. H. Taha, *Operations Research – An Introduction*. Prentice Hall
2. Hillier and Lieberman, *Introduction to Operations Research*, McGraw Hill.
3. G. Hadly, *Linear Programming*, Narosa Publishing House
4. J. K. Sharma, *Operations Research – Theory and Application*, Macmillian Pub.
5. J. K. Sharma, *Operations Research – Problems and Solutions*, Macmillian Pub.

# B. A./ B. Sc. (Hons.) Mathematics, Semester – III

| BHM-3.1 Analysis –I | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Bounded and unbounded sets, Infimum and supermum of a set and their properties, Order completeness property of R, Archimedian property of R, Density of rational and irrational numbers in R, Dedekind form of completeness property, Equivalence between order completeness property of R and Dedekind property. Neighbourhood, open set, Interior of a set, Limit point of a set, Closed set and related Theorems/results. Derived set, Closure of a set, Bolzano-Weierstrass theorem for sets. Countable and uncountable sets.

**Unit-II** Sequence of real numbers, Bounded sequence, limit points of a sequence, Bolzano Weierstrass theorem for sequence, Limit inferior and limit superior, Convergent and non-convergent sequences, Cauchy's sequence, Cauchy's general principal of convergence, Algebra of sequences, Theorems on limits of sequences, Subsequences, Monotone sequences, Monotone convergence Theorem.

**Unit-III** Infinite series and its convergence and divergence, Cauchy's criterion for convergence of series, Test for convergence of positive term series, Comparison tests, Ratio test, Cauchy's $n^{th}$ root test, Raabe's test, Logrithmic test, Integral test, Alternating series, Leibnitz test, Absolute and conditional convergence.

**Unit-IV** Continuous functions ($\varepsilon - \delta$ approach), Discontinuous functions, Types of discontinuities, Sequential criterion for continuity and discontinuity, Theorems on continuity, Uniform continuity, Relation between continuity and uniform continuity, Derivative of a function, Relation between continuity and differentiability, Increasing and decreasing functions, Darboux theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Taylor's theorem with Cauchy's and Lagrange's form of remainder.

**Books Recommended:**


1. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis (*$3^{rd}$ *Edition)*, John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2003.
2. S. C. Malik and Savita Arora, *Mathematical Analysis,* New Age International (P) Ltd. Publishers, 2009.
3. K. A. Ross, *Elementary Analysis: The Theory of Calculus, under graduate Texts in Mathematics,* Springer (SIE), Indian reprint, 2004.
4. Sudhir R. Ghorpade and Balmohan V. Limaye, *A course in Calculus and Real Analysis, Undergraduate Text in Maths.,* Springer (SIE), Indian reprint 2006.
5. T. M. Apostol, *Mathematical Analysis,* Addison-Wesley Series in Mathematics, 1974.
6. Gerald G. Bilodeau, Paul R. Thie, G. E. Keough, *An Introduction to Analysis,* $2^{nd}$ Ed., Jones & Bartlett, 2010.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – III

| BHM-3.2 Group Theory | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Sets, Relations, Functions, Binary operations, Definition of groups with examples and its properties, Subgroups, Order of an element of a group, Cyclic groups, Cosets, Lagrange's theorem and its consequences, Normal subgroup and Commutator subgroups, Factor groups.

**Unit-II** Group Homomorphism, Isomorphisms, Kernel of a homomorphism, The homomorphism theorems, The Isomorphism theorems, Permutation groups, Even and Odd permutations, Alternating groups, Cayley's theorem and Regular permutation group

**Unit-III** Automorphism, Inner automorphism, Automorphism group of finite and infinite cyclic groups, Conjugacy relation, Normalizer and Centre, External direct products, definition and examples of Internal direct products.

**Unit-IV** Class equation of a finite group and its applications, Structure of finite Abelian groups, Cauchy's theorem, Sylow's theorem and consequences, Definition and example of Simple groups, Non-simplicity tests.

**Books Recommended:**


1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern Ltd., New Delhi.
2. Joseph A. Gallian, *Contemporary Abstract Algebra (4th Ed*), Narosa Publishing House, New Delhi.
3. N. Jacobson, *Basic Algebra Vol. I & II*, W. H. Freeman.
4. Surjeet Singh and Qazi Zameeruddin, *Modern Algebra*, Vikas Publishing House Pvt., Ltd., New Delhi
5. N S Gopalakrishan, *University Algebra*, New Age International (P) Limited, New Delhi.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – III

| BHM-3.3 Numerical Methods | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Absolute, relative and percentage errors, General error formula. Solution of algebraic and transcendental equations: Bisection method, False position method, Fixed-point iteration method, Newton's method and its convergence, Chebyshev method. Solution of system of non-linear equations by Iteration and Newton-Raphson method.

**Unit-II** Direct methods to solve the system of linear equations: Gauss elimination method, Gauss Jordan method, LU decomposition method. Indirect methods: Gauss-Jacobi and Gauss-Seidal methods. The algebraic Eigen value problems by Householder and Power method.

**Unit-III** Finite difference operators and finite differences, Interpolation and interpolating polynomials: Newton's forward and backward difference formulae, Central differences: Sterling's and Bessel's formula. Lagrange's interpolation formula, Divided Differences, their properties and Newton's general interpolation formula. Inverse interpolation.

**Unit-IV** Numerical differentiation of tabular and non-tabular functions. Numerical integration using Gauss quadrature formulae: Trapezoidal rule, Simpson's rules, Romberg formula and their error estimation. Numerical solution of ordinary differential equations by Picard's method, Taylor series, Euler's method and Runge-Kutta methods. Multi-step method: Adams-Moulton method.

**Books Recommended**:


1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition, 2007
3. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008.
4. S. S. Sastry, Introductory Methods of Numerical Analysis (Fifth Ed.), Prentice Hall of India (Ltd.) New Delhi-110001, 2012.
5. M. Pal, Numerical Analysis for Scientists and Engineers, Narosa Publisher, 2007.
6. N. Ahmad, Fundamental Numerical Analysis with error estimation, Anamaya Publisher.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – IV

| BHM-4.1 | Analysis-II | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | | 4 | 4 | 4 |

**Unit-I** Definition, existence and properties of Riemann integral of a bounded function, Darboux theorem, Condition of integrability, Riemann integrability for continuous functions, monotonic function and theorems on function with finite or infinite number discontinuity (without proof). The Riemann integral through Riemann sums, Equivalence of two definitions, Properties of Riemann integral, Fundamental theorem of calculus, First Mean Value Theorems, Second Mean Value Theorems, Generalized Mean Value Theorems.

**Unit-II** Definition of improper integrals, Convergence of improper integrals, Test for convergence of improper integrals, Comparison test, Cauchy's test for convergence, Absolute convergence, Abel's Test, Dirichlet's Test, Beta and Gamma functions and their properties and relations.

**Unit-III** Pointwise and uniform convergence of sequences and series of functions, Cauchy's criterion for uniform convergence of sequence and series, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and differentiation, Uniform convergence and integration, Weierstrass Approximation Theorem.

**Unit-IV** Fourier Series, Fourier Series for even and odd functions, Half Range Series, Fourier Series on intervals other than $[-\pi, \pi]$.

Power Series, Radius of Convergence, Cauchy's Hadamard Theorem, Uniform and Absolute convergence, Abel's Theorem (without proof), exponential and logarithmic functions.

**Books Recommended:**


1. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis ($3^{rd}$ Edition),* John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2003.
2. S. C. Malik and Savita Arora, *Mathematicla Analysis,* New Age International (P) Ltd. Publishers, 2009.
3. K. A. Ross, *Elementary Analysis: The Theory of Calculus, Under graduate Texts in Mathematics,* Springer (SIE), Indian reprint, 2004.
4. Sudhir R. Ghorpade and Balmohan V. Limaye, *A course in Calculus and Real Analysis, Undergraduate Text in Maths.,* Springer (SIE), Indian reprint 2006.
5. T. M. Apostol, *Mathematical Analysis,* Addison-Wesley Series in Mathematics, 1974.
6. Gerald G. Bilodeau, Paul R. Thie, G. E. Keough, *An Introduction to Analysis,* $2^{nd}$ Ed., Jones & Bartlett, 2010.
7. A. Mattuck, *Introduction to Analysis,* Prentice Hall, 1990.
8. Charles G. Denlinger, *Elements of Real Analysis,* Jones & Bartlett (Student Edition), 2011.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – IV

| BHM-4.2 Differential Equations – II | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Total differential equations, Simultaneous total differential equations, Equations of the form $dx/P = dy/Q = dz/R$, Methods of grouping and multipliers, Solution of a system of linear differential equation with constant coefficients, An equivalent triangular system, Degenerate case.

**Unit-II** Formation and solution of a partial differential equations, Equations easily integrable. Linear partial differential equations of first order- Lagrange's equation, Non-linear partial differential equation of first order- Solution of some standard type of equations, Charpit's method.

**Unit-III** Homogeneous linear partial differential equations of second and higher orders with constant coefficients, Different cases for complimentary functions and particular integrals, Non-homogeneous partial differential equations with constant coefficients, Classification of second order linear partial differential equations, Partial differential equations reducible to equations with constant coefficients, Monge's method.

**Unit-IV** Variation of a functional, Variational problems, Euler's equations and its various cases, Externals, Functional depending on n unknown functions, Functionals depending on higher order derivatives, Variational problems in parametric form, Isoperimetric problem, Canonical form of Euler's equation, Functionals depending on functions of several independent variables, Ostrogradsky's equation.

**Books Recommended:**


1. Dennis G. Zill, A first course in differential equations,
2. Tyn Mint-U and Lokenath Debnath, Linear Partial Differential Equations
3. D.A. Murray: Introductory Course on Differential Equations, Orient Longman (India), 1967.
4. A.S. Gupta: Calculus of variations with applications, Prentice Hall of India, 1997.
5. I.N. Sneddon: Elements of Partial Differential Equations, McGraw Hill Book Company, 1988.
6. Zafar Ahsan: Differential Equations and their Applications, Prentice Hall of India, New Delhi (2nd Edition, 13th reprint May 2012).

## B. A./ B. Sc. (Hons.) Mathematics, Semester – IV

| BHM-4.3 Ring Theory | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Rings and their properties, Boolean Ring, Integral domain, Division ring and Field, Subrings, Ideals and their properties, Operations on ideals, Ideal generated by a subset of a ring, Quotient rings.

**Unit-II** Homomorphism of rings and its properties, Kernel of a homomorphism, Natural homomorphism, Isomorphism and related theorems, Field of quotients.

**Unit-III** Polynomial rings over commutative rings, Properties of $R[X]$, Division algorithm and its consequences, Factorization of polynomials, Irreducibility test, Eisenstein's criterion for irreducibility.

**Unit-IV** Factorization in integral domains, prime and irreducible element, Principal Ideal Domain, Euclidean Domain, Unique Factorization Domain and its properties.

**Books Recommended:**


1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern Ltd., New Delhi.
2. N. Jacobson: *Basic Algebra*, Volume I and II. W. H. Freeman and Co.
3. Surjeet Singh and Qazi Zameeruddin: *Modern Algebra*, Vikas Publication.
4. J.A. Gallian, *Contemporary Abstract Algebra*, Narosa Publication.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – V

| BHM-5.1 Functions of Several Variables | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Functions of several variables. Domains and Range. Functional notation, Level curves and level surfaces. Limits and continuity. Partial derivatives. Total differential. Fundamental lemmas. Differential of functions of n variables and of vector functions. The Jacobian matrix. Derivatives and differentials of composite functions, The general chain rule.

**Unit-II** Implicit functions. Inverse functions. Curvilinear co-ordinates. Geometrical Applications. The directional derivatives. Partial derivatives of higher order. Higher derivatives of composite functions. The Laplacian in polar, cylindrical and spherical co-ordinates. Higher derivatives of implicit functions. Maxima and minima of functions of several variables.

**Unit-III** Vector fields and scalar fields. The gradient field. The divergence of a vector field. The curl of a vector field. Combined operations. Irrotational fields and Solenoidal fields. Double integrals, triple integrals and multiple integrals in general. Change of variables in integrals. Arc length and surface area.

**Unit-IV** Line integrals in the plane. Integrals with respect to arc length. Basic properties of line integrals. Line integrals as integrals of vectors. Green's Theorem. Independence of path, Simply connected domains, Extension of results to multiply connected domains. Line Integrals in space. Surfaces in space, orientability. Surface integrals. The divergence theorem. Stokes's theorem. Integrals independent of path.

**Books Recommended:**


1. Wilfred Kaplan: Advanced Calculus.,Adisson-Wasley Publishing Company,1973.
2. E. Swokowski: Calculus with Analytical Geometry, Prindle, Weber & Schmidt, 1994
3. E. Kreyzig: Advanced Engineering Mathematics, John Wiley and Sons, 1999.
4. David Widder: Advanced Calculus, Prentice Hall of India, 1999.
5. S. C Malik and Savita Arora: Mathematical Analysis, New Age International(P)1996

## B. A./ B. Sc. (Hons.) Mathematics, Semester – V

| **BHM-5.2** | **Metric Spaces** | **Unit** | **Credit** | **Lecture/ week** |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | | 4 | 4 | 4 |

**Unit-I** Definition and examples of metric spaces, open spheres and closed spheres, Neighbourhood of a point, Open sets, Interior points, Limit points, Closed sets and closure of a set, Boundary points, diameter of a set, Subspace of a metric space.

**Unit-II** Convergent and Cauchy sequences, Complete metric space, Dense subsets and separable spaces, Nowhere dense sets, Continuous functions and their characterizations, Isometry and homeomorphism. Fixed points and contraction mapping, Banach's contraction Theorem.

**Unit-III** Compact spaces, Sequential compactness and Bolzano-Weierstrass property, Finite Intersection property, Continuous functions and compact sets.

**Unit-IV** Disconnected and connected sets, connected subsets of R, Continuous functions and connected sets.

**Books Recommended:**


1. G.F. Simmons: *Introduction to Topology and Modern Analysis*, McGraw Hill, 1963.
2. E.T. Copson, *Metric spaces*, Cambridge University Press, 1968.
3. P.K. Jain and Khalil Ahmad: *Metric spaces*, Second Edition, Narosa Publishing House, New Delhi, 2003.
4. B. K. Tyagi, *first course in metric spaces,* Cambridge University Press, 2010.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – V

| BHM-5.3 Linear Algebra | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit-I** Definition examples and basic properties of a vector space, Subspaces, Linear Dependence Independence, Linear combinations and span, Basis and dimension, Sum and intersection of subspaces, Direct sum of subspaces.

**Unit-II** Definition and examples of linear transformations, Properties of linear transformations, Range and kernel, The rank and nullity of a linear transformation, Rank-Nullity Theorem and its consequence, The matrix representation of a linear transformation, Change of basis, Isomorphism.

**Unit-III** Scalar product in an Inner product spaces. Orthogonality in inner product Spaces, Normed linear spaces, Inner product on complex vector spaces, Orthogonal Complements, orthogonal sets and projections, Gram-Schmidt Orthogonalization process, Bessel's inequality.

**Unit-IV** Eigenvalues and Eigen vectors, Characteristic equation and polynomial, Eigenvectors and eigenvalues of linear transformations and matrices, The Cayley-Hamilton Theorem. Similar matrices and Diagonalization, Eigenvalues and eigenvectors of symmetric and Hermitian matrices, Orthogonal Diagonalization, Quadratic forms and conic sections.

**Books Recommended:**


1. David C. Lay: *Linear algebra and its applications (3rd Edition),* Pearson Education, Asia, Indian Reprint, 2007.
2. Geory Nakos and David Joyner: *Linear algebra with Applications*, Brooks/ Cole, Publishing Company, International Thomson Publishing, Asia, Singapore, 1998.
3. Stephen H. Friedberg, Arnold J. Insel and L.E.Space- *Linear Algebra*, 4th dition, PHI Pvt Ltd., New Delhi, 2004.
4. I. V. Krishnamurty, V.P. Mainra, J.L. Arora- *An introduction to Linear Algebra*, East West Press , New Delhi, 2002.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – VI

| BHM-6.1 Mechanics | Unit | Credit | Lecture/ week |
|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | 4 | 4 | 4 |

**Unit I**: Moment of force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading.

**Unit II**: Laws of friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorem, relation between second moments and products of area, polar moment of area, principal axes.

**Unit III**: Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles.

**Unit IV**: Translation and rotation of rigid bodies, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references, motion of a particle relative to a rotating frame of reference, frame of reference in general motion.

**Books Recommended**


1. I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, ($4_{th}$ Ed.) Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. John L. Synge Byron A. Griffith, Principle of Mechanics, Mc GrawHill International Student Edition.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – VI

| BHM-6.2 | Geometry of Curves and Surfaces | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | | 4 | 4 | 4 |

**Unit-I** Tensors: Summation convention, co-ordinate transformation, Scalar, contravariant and covariant vectors, Tensors of higher rank, Algebra of tensors and contraction, Metric tensor and 3-index christofell symbols, covariant derivative of contravariant, covariant vectors and higher rank tensors.

**Unit-II** Curves in $R^3$: Representation of curves, unit speed curves, tangent to a curve, principal vector and binormal vector , osculating plane, normal plane and rectifying plane, curvature and torsion, Serret - Frenet formula, Helix.

**Unit-III** Behavior of curve near a point, osculating circle and osculating sphere, Necessary and sufficient condition for a curve to lie on a sphere, involutes and evolutes, Fundamental existence theorem for space curves.

**Unit-IV** Surface in $R^3$: Definition and examples of a smooth surface, tangent plane and unit surface normal, Surface of revolution, first fundamental form and its properties, Direction co-efficient on a surface, angle between tangential direction on a surface, second fundamental form, normal curvature, Principal curvature, Shape operator and its properties.

**Books Recommended**


1. Elementary Differential Geometry, B.O. Neill, Academic Publishers.
2. Elementary Differential Geometry, Andrew Pressley, Springer.
3. Differential Geometry of Curves and Surfaces, M. P. do Carmo, Prentice Hall.
4. Introduction to Differential geometry, t. G. Willmore, Oxford University Press.
5. Differential Geometry, D. Somasundaram, Narosa Publishing House.

## B. A./ B. Sc. (Hons.) Mathematics, Semester – VI

| BHM-6.3 | Complex Analysis | Unit | Credit | Lecture/ week |
|---|---|---|---|---|
| Internal Assessment: 25 Marks<br>End Semester Examination: 75 Marks<br>Duration of Examination: 2 Hrs | | 4 | 4 | 4 |

**Unit-I** Complex number system, Algebraic properties, Geometric interpretation, exponential forms, powers and roots, Properties of moduli, Regions in complex plane, Limit, continuity and derivatives.

**Unit-II** Analytic functions, CR equations, sufficient conditions, polar conditions, Harmonic functions, Construction of analytic function, Line integral.

**Unit-III** Cauchy Goursat theorem, Cauchy integral formula, Derivatives of analytic function, Fundamental theorem of calculus in the complex plane, Taylor's and Laurent series.

**Unit-IV** Definitions and examples of conformal mappings, Zeros of analytic function, Residues, Residue at poles, Residue theorem, Evaluation of Integrals involving sine and cosine series.

**Books Recommended**


1. R.V. Churchill and J W Brown: Complex Variable & Applications. McGraw Hill, International Book Company, London.
2. Punnuswamy: An Introduction to Complex Analysis, Narosa Publication