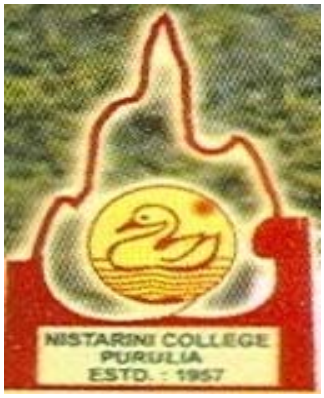
Department of Mathematics

NISTARINI COLLEGE, PURULIA

NAAC Accredited with 'A' Grade (CGPA 3.20) in 2023
(Affiliated to Sidho-Kanho-Birsha University, Purulia, W.B.)



3/4 Year Undergraduate Course

under

Curriculum and Credit Framework for Undergraduate Program (CCFUP)

(NEP 2020)

Mathematics Curriculum with Course Objectives, Course Outcomes, Programme Specific Outcomes & Programme Outcomes

DESHBANDU ROAD PURULIA-723101

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Programme Outcomes: B. Sc.

PO-1 Students pass out this programme become adept in hands-on activities

PO-2 Students get conversant with different recent trends of scientific works happening in and around

PO-3 Students become workable and thus if they want they can opt for job and/or such training courses

PO-4 Students become highly cognizant of the expansion of the learning in their respective field which enables them to get admitted to the premier institutes of the country

PO-5 An aptitude to research is also stimulated in the mind soft his budding generation which prompts them to take up some projects in good laboratories of the country after completing the programme

PO-6 One most significant outcome of the programme is the in culcation of higher values of life among the learners that enable them to face any hazard of the future life.

Programme Specific Outcomes: B.Sc. in Mathematics

PSO-1 Development of logical and analytical skills for abstract thinking which is required for higher studies

PSO-2 Learn advanced topics in Mathematics that will pave their way for further studies in Mathematics

PSO-3 Formulate and develop mathematical arguments in a logical manner

PSO-4 Acquire good knowledge and understanding in advanced areas of Mathematics and Statistics from the given courses

PSO-5 Formulation of mathematical problems from real life situations, their analysis and possible solutions

PSO-6 Learn mathematical techniques required for jobs in educational, banking, corporate, IT sectors, etc.

MAJOR COURSES

(Students have to study these courses in all Eight Semesters)

SEMESTER 1

Paper: Major–1 **Code: BMTMMAJ01T**

Title: Classical Algebra, Analytical Geometry (2D) & Calculus.

Syllabus: **Credit: 6**

Unit -1: Classical Algebra **[Credit: 2, 30 L]**

- Complex Numbers: De-Moivre's Theorem and its applications, Direct and inverse circular and hyperbolic functions, Exponential, Sine, Cosine and Logarithm of a complex number.
- Polynomial equation, Fundamental theorem of Algebra (Statement only), Multiple roots, Statement of Rolle's theorem only and its applications, Equation with real coefficients, Complex roots, Descartes' rule of sign, relation between roots and coefficients, transformation of equation, reciprocal equation, binomial equation– special roots of unity, solution of cubic equations–Cardan's method, solution of biquadratic equation– Ferrari's method.
- Inequalities involving arithmetic, geometric and harmonic means. Schwarz and Weierstrass's inequalities.

Unit -2: Analytical Geometry (2D) **[Credit: 2, 30 L]**

- Transformation of Rectangular axes: Translation, Rotation and Rigid body motion, Invariants.
- Pair of straight lines: Condition that the general equation of second degree in two variables should represent a pair of straight lines, Angle between pair of straight lines, Bisectors of angle between the pair of straight lines, Equation of two lines joining the origin to the points in which a line meets a conic.
- General Equation of second degree in two variables: Reduction into canonical form.
- Polar Equations: Polar Co-ordinates, Polar equation of straight lines, Circles, conics referred to a focus as pole. Equations of tangents, normal.

Unit -3: Calculus **[Credit: 2, 30 L]**

- Differential Calculus: Higher order derivatives, Leibnitz rule of successive differentiation and its applications; Indeterminate forms, L'Hospital's rule; Basic ideas of Partial derivatives, Chain Rules, Jacobian, Euler's theorem and its converse; Tangents and Normals, Sub-tangent and sub-normals, Derivatives of arc lengths, Pedal equation of a curve; Curvature and radius of curvature; Asymptotes; Envelopes; Concavity, convexity and point of inflexion.
- Integral Calculus: Reduction formulae; Rectification & quadrature of plane curves, length of a curve; Arc length as a parameter; Volume and surface area of revolution.

Reading References:

1. S.K. Mapa, Higher Algebra (Classical), Levant.
2. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
3. W.S. Burnstine and A.W. Panton, Theory of equations, Wentworth Press.
4. J.G. Chakraborty & P.R. Ghosh, Advanced Analytical Geometry, U.N. Dhur & Sons Pvt. Ltd.
5. S.L. Loney, The Elements of Coordinate Geometry (Part 1), Arihant.
6. R. M. Khan, Analytical Geometry of two & three dimensions and vector analysis, New Central Book Agency (P) Ltd.
7. Arup Mukherjee and Naba Kumar Bej, Analytical Geometry of Two and Three Dimensions (Advanced level), Books & Allied Pvt. Ltd.
8. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005
9. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
10. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

11. T.M. Apostol, Calculus, Volumes I and II, Wiley Edition.
12. Shanti Narayan, P. K. Mittal, Differential Calculus, S. Chand.
13. Maity & Ghosh, Integral Calculus, New central book agency (P) Ltd.

COURSE OBJECTIVES:

To develop a strong foundation in Classical Algebra and enhance understanding of Two-dimensional Analytical Geometry
To learn some key concepts in Differential & Integral Calculus

COURSE OUTCOMES:

CO-1 Understanding of De-Moivre's theorem, Rolle's theorem and their applications

CO-2 Learn methods to solve equations, transformed equations, cubic, bi-quadratic and reciprocal equations

CO-3 Familiarize with A.M, G.M, & H.M and useful inequalities

CO-4 Understanding of Transformation of Axes and its uses for the reduction of General Equation of Second Degree to Canonical form

CO-5 Understanding geometry of two-dimensional plane figures with special emphasize on pair of straight lines

CO-6 Familiarize with Polar Co-ordinate system and polar equation of line, circle, conics & tangent and normal to conics

CO-7 Familiarize with Higher Order Derivatives & Leibnitz Rule for Successive Differentiation with its applications

CO-8 Understanding of Intermediate Forms & L'Hospital's Rule

CO-9 Understanding the basic ideas Partial Derivatives and applications of Euler's Theorem

CO-10 Familiarize with applications of Differential Calculus and Integral Calculus

SEMESTER 2

Paper: Major–2 **Code: BMTMMAJ02T**

Title: Algebra–I & Real Analysis–I

Syllabus: **Credit: 6**

Unit -1: Algebra-I **[Credit: 2, 30 L]**

- **Relation:** Equivalence relation, equivalence classes and partition, partial ordered relation. Hesse's diagram, Lattices as partially ordered set, definition of lattice in terms of meet and join, equivalence of two definitions, linear order relation.
- **Mappings:** Injective, surjective, one-to-one correspondence, composition of two mappings. Inversion of mappings. Extension and restriction of a mappings.
- Principles of Mathematical Induction, Well-ordering Principle, Division Algorithm, Greatest common divisor, Primes and composite numbers, Fundamental theorem of arithmetic, 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 – Fermat's theorem, Chinese remainder theorem, Number of divisors of a number and their sum, least number with given number of divisors.
- Eulers φ function-φ(n). Mobius μ-function, relation between φ function and μ function. Diophantine equations of the form $ax + by = c$, a, b, c are integers.
- **Group:** Groupoid, semigroup, monoid and quasigroup (definitions and examples). Group, uniqueness of identity and inverse element, law of cancellation, order of a group and order of an element, abelian group, elementary properties of group.
- Definitions of rings and fields with examples.

Unit -2: Real Analysis-I **[Credit: 4, 60 L]**

- Review of Algebraic and Order Properties of $\mathbb{R}$, ε-neighbourhood of a point in $\mathbb{R}$. Idea of countable sets and countability of $\mathbb{R}$, uncountable sets and uncountability of $\mathbb{R}$. Boundedness. Suprema and Infima. Completeness Property of $\mathbb{R}$ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$.
- **Point Set Theory in R:** Intervals. Interior points of a set, open sets. Limit points of a set, isolated points, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets.
- **Sequences:** Real sequence, Bounded sequence, Limit of a sequence, Convergent sequence, liminf, limsup. Limit Theorems. Monotone Sequences, Monotone Convergence Theorem. Sandwich Rule, Nested interval theorem, Cauchy's first and second limit theorem. Subsequences, Divergence Criteria. Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.
- **Infinite series:** Convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio test, Cauchy's nth root test, Raabe's test (proof not required), Gauss's test (proof not required), Cauchy's condensation test (proof not required), Integral test (proof not required). Alternating series, Leibnitz test (proof not required). Absolute and Conditional convergence. Re-arrangement of terms (concepts and elementary examples only).
- **Limits:** Concepts of limits of a function (ε-δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity.
- **Continuity:** Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

- **Differentiability:** Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem. Intermediate value property. Darboux's theorem (statement only). Applications of mean value theorem to inequalities and approximation of polynomials. Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions. Application of Taylor's theorem to inequalities.

Reading References:

1. Sen, Ghosh, Mukhopadhaya, Maity; Topics in Abstract Algebra; Universities Press.
2. S. K. Mapa, Higher Algebra (Abstract and Linear), Levant.
3. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002
4. Joseph A. Gallian; Contemporary Abstract Algebra; 9th Ed..; Narosa Pub. H.; New Delhi, 1999.
5. D.S. Malik, John M. Mordeson and M.K. Sen; Fundamentals of abstract algebra; McGraw-Hill.
6. T.M. Apostol; Introduction to Analytic Number Theory; Springer.
7. I. Niven, H.S. Zuckerman, H.L. Montgomery; An Introduction to Theory of Numbers; 5th Ed.; John Wiley & Sons, Inc.
8. A.K. Chowdhury; Introduction to Number Theory; 2nd Ed.; NCBA.
9. R.G. Bartle and D. R. Sherbert; Introduction to Real Analysis; 3rd Ed.; John Wiley and Sons (Asia) Pvt. Ltd.; Singapore; 2002.
10. S.K. Berberian; A First Course in Real Analysis; Springer-Verlag; New York; 1994.
11. W. Rudin; Principles of Mathematical Analysis; Tata McGraw-Hill.
12. S.K. Mapa; Introduction to Real analysis; Levant.
13. S.C. Malik & Savita Arora; Mathematical Analysis; New Age International (P) Limited.
14. S.R. Ghorpade and B.V. Limaye; A Course in Calculus and Real Analysis: Springer: 2006.
15. Tom M. Apostol; Mathematical Analysis; Narosa Publishing House.
16. Charles G. Denlinger; Elements of Real Analysis; Jones & Bartlett (Student Edition); 2011.
17. Richard R. Goldberg; Methods of Real Analysis; 2nd Ed.; John Wiley and Sons, Inc.

COURSE OBJECTIVES:

To develop an in-depth understanding of algebraic structures such as equivalence relations, mappings, groups, congruences.
To build fundamental knowledge in real analysis, focusing on sequences, series, limits, continuity, differentiability and related theorems

COURSE OUTCOMES:

CO-1 Concept of Mappings, Equivalence Relation and Lattice

CO-2 Concept of Mathematical Induction & Fundamental Theorem of Arithmetic

CO-3 Understanding of Euclid's Algorithm, GCD, LCM

CO-4 Understand the definitions of congruence, power of congruence and related theorems

CO-5 Familiarize with Euler's φ-function , Mobius μ-function and Solution of Diophantine Equation

CO-6 Concept of Groups, Rings and Fields and their properties

CO-7 Understand algebraic & order properties of Real numbers and completeness of Real numbers

CO-8 Idea of countable and uncountable sets, open sets and closed sets

CO-9 Concept of Sequence and Series of Real numbers and their convergences

CO-10 Concept of Limit, Continuity & Differentiability of functions of one variable

CO-11 Mean value theorems and their applications

CO-12 Finding series expansion of various functions

SEMESTER 3

Paper: Major–3 **Code: BMTMMAJ03T**

Title: Ordinary Differential Equations & Linear Algebra-I

Syllabus: **Credit: 6**

Unit -1: Ordinary Differential Equations **[Credit: 3, 45 L]**

- Prerequisite [Genesis of differential equation: Order, degree and solution of an ordinary differential equation, Formation of ODE, Meaning of the solution of ordinary differential equation, Concept of linear and non-linear differential equations].
- Picard's existence and uniqueness theorem (statement only) for $\frac{dy}{dx} = f(x, y)$ with $y = y_0$ at $x = x_0$ and its applications.
- **Solution of Differential Equations of first order and first degree:** Homogeneous equations and equations reducible to homogenous form. Exact differential equations, condition of exactness, Integrating Factor, Rules of finding integrating factor (statement of relevant results only), equations reducible to exact forms, Linear Differential Equations, equations reducible to linear forms, Bernoulli's equations.
- **Solution of Differential Equations of first order but not of first degree:** Equations solvable for p, equations solvable for x, equation solvable for y, singular solutions, Clairaut's form, equations reducible to Clairaut's Forms - General and Singular solutions.
- **Applications of first order differential equations:** Geometric applications, Orthogonal Trajectories.
- **Solution of Differential Equations of higher order:** Linear differential equations of second and higher order, Linearly dependent and independent solutions, Wronskian, General solution of second order linear differential equation, General and particular solution of linear differential equation of second order with constant coefficients. Particular integrals for polynomial, sine, cosine, exponential function and for function as combination of them or involving them, Method of variation of parameters for particular integral (P.I.) of linear differential equation of second order
- Linear Differential Equations with variable co-efficients, Euler- Cauchy equations, Exact differential equations, Reduction of order of linear differential equation, Reduction to normal form. Solutions of some special types of differential equations.
- Simultaneous linear ordinary differential equation in two dependent variables, Solution of simultaneous equations of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$.
- Pfaffian Differential Equation $Pdx + Qdy + Rdz = 0$, Necessary and sufficient condition for existence of integrals of the above (proof not required), Total differential equations.

Unit -2: Linear Algebra-I **[Credit: 3, 45 L]**

- Vector space, subspaces, Linear Sum, linear span, linearly dependent and independent vectors, basis, dimension, finite dimensional vector spaces, Replacement Theorem, Extension theorem, Deletion theorem, change of coordinates, Row rank and column rank of a matrix. Rank of a matrix. Row reduced echelon matrix, Normal form of the matrix.
- Systems of linear equations and the matrix equation $Ax = b$. Existence of solutions of homogeneous and non-homogeneous system of equations and determination of their solutions.
- Characteristic Equation of a matrix, Cayley-Hamilton theorem (statement only) and its applications. Eigen values, Eigen Vectors of a matrix, Similar matrices, Diagonalization of matrices of order 2 and 3.

Reading References:

1. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
2. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
3. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
4. G.F. Simmons, Differential Equations, Tata McGraw Hill
5. Ghosh and Chakraborty, Differential Equations, U N Dhur
6. Maity and Ghosh, An Introduction to Differential Equations, New Central Book Agency
7. G. C. Gorain, Introductory course on Differential Equations
8. S. K. Mapa, Higher Algebra, Vol. – II, Academic Publishers
9. Hoffman, K. and Kunze, R., Linear Algebra, Pearson
10. Finkbeincr, Matrices and Linear Algebra

COURSE OBJECTIVES:

To impart details knowledge on Ordinary Differential Equations, concepts of vector space and eigen values & eigen vectors of a matrix.

COURSE OUTCOMES:

CO-1 Familiarize with First order linear Ordinary Differential Equations and their solution techniques

CO-2 Identification and solution techniques of First order non-linear Ordinary Differential Equations

CO-3 Understanding of applications of First order Ordinary Differential Equations, Orthogonal Trajectories

CO-4 Familiarize with different solution techniques of Higher order linear Ordinary Differential Equations with constant co-efficients and variable co-efficients

CO-5 Understanding simultaneous linear Ordinary Differential Equations and Total Differential Equations

CO-6 Concept of vector space, Basis and Dimension of a finite dimensional vector space

CO-7 Understanding the concept of Row rank, Column rank & Rank of a matrix and Row reduced Echelon form & Normal form of matrix

CO-8 Acquainted with the Existence of solutions of system of Linear Equations and their solution techniques

CO-9 Concept of Eigen values and Eigen vectors of a matrix and Diagonalization of Matrices of order 2 and 3

SEMESTER 4

Paper: Major–4 **Code: BMTMMAJ04T**

Title: Abstract Algebra–I & Multivariate Calculus

Syllabus: **Credit: 6**

Unit -1: Abstract Algebra-I **[Credit: 3, 45 L]**

- Subgroup-Necessary and sufficient condition. Subgroup generated by a subset. Finite Group, Simple examples, Centralizer, Normalizer, Center of a group, Product of two subgroups.
- Symmetries of a square, Dihedral groups, Permutation groups, Symmetric groups and Quaternion groups (through matrices).
- Cyclic group, properties of cyclic groups, classification of subgroups of cyclic groups, Cycle notation for permutations, properties of permutations, even and odd permutations, Alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.
- Normal Subgroups, Quotient Group.
- Group homomorphism and isomorphism and their properties. Cayley's theorem. First, Second and Third Isomorphism Theorems. Correspondence theorem for groups.
- Subrings, Ideals, Divisor of zero, Unit, Idempotent element, Nilpotent element, Integral Domains, Quotient Ring, Quotient field, Characteristic of a Ring, Subfield. Ring Homomorphism, Isomorphism. First, Second and Third Isomorphism theorems.

Unit -2: Multivariate Calculus **[Credit: 3, 45 L]**

- Functions of several variables, limit and continuity of functions of two or more variables.
- Partial differentiation, total differentiability, sufficient condition for differentiability, Schwartz and Young's theorems (statement only) and their verification. Directional derivatives, the gradient, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.
- Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of order in double integrals and triple integrals.

Reading References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999, Narosa Publishing House, New Delhi.
4. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
5. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra, McGraw-Hill Education-Europe.
6. Sen, Ghosh, Mukhopadhaya, Maity; Topics in Abstract Algebra; Universities Press.
7. S. K. Mapa, Higher Algebra (Abstract and Linear), Levant.
8. Tom M. Apostol, Mathematical Analysis, Narosa Book Distributors Pvt. Ltd.-New Delhi.
9. Shanti Narayan, P.K. Mittal, Integral Calculus, S. Chand.
10. Maity & Ghosh, Integral Calculus, New Central Book Agency (P) Ltd.

COURSE OBJECTIVES:

To impart details knowledge of abstract algebra including concept on isomorphism & homomorphism of Groups & Rings; also build up concepts on Functions of Several Variables and Double & Triple Integrations with applications

COURSE OUTCOMES:

CO-1 Concept of Subgroups, Finite group, Centralizer, Normalizer & Centre of a group

CO-2 Understanding the concept of Dihedral group, Permutation group, Symmetric groups and Quaternion groups

CO-3 Concept of Cyclic group and its properties, Alternating group, Cosets, Normal Subgroup, Quotient group

CO-4 Learn Lagrange's theorem and it's consequences including Fermat's little theorem

CO-5 Understanding Group Homomorphism & Isomorphism; First, Second & Third Isomorphism theorems; Cayley's theorem

CO-6 Understand the concept of Rings and Fields, Ideals, Integral Domains, Quotient Ring

Paper: Major–5 **Code: BMTMMAJ05T**

Title: Analytical Geometry (3D), Vector Calculus & Partial Differential Equations

Syllabus: **Credit: 6**

Unit -1: Analytical Geometry (3D) **[Credit: 2, 30 L]**

- Plane; Straight lines.
- **Sphere:** General Equation, Circle, Sphere through circle, Tangent, Normal.
- **Cone:** General homogeneous second degree equation, Enveloping cone, Section of cone by a plane, Tangent and normal, Condition for three perpendicular generators, Reciprocal cone, Right circular cone, Cylinder, Enveloping cylinder, Right circular Cylinder.
- **Conicoids:** Ellipsoid, Hyperboloid, Paraboloid: Canonical equations only. Plane sections of it.
- Transformation of coordinates, Reduction of general second degree equations.

Unit -2: Vector Calculus **[Credit: 2, 30 L]**

- Product of three or more vectors.
- Vector Calculus: Continuity and differentiability of vector-valued function of one variable, Space curve, Arc length, Tangent, Normal. Serret-Frenet's formulae. Integration of vector-valued function of one variable.
- 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, surface and volume integrals.
- Green's theorem in the plane. Gauss and Stokes' theorems (Proof not required) and problems based on these.

Unit -3: Partial Differential Equation **[Credit: 2, 30 L]**

- **Partial Differential Equations:** Basic concepts and Definitions. Mathematical Problems. First-Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First- order Linear Equations. Method of Separation of Variables for solving first order partial differential equations. Solution by Lagrange's and Charpit's method.

Reading References:

1. S.L. Loney; The Elements of Coordinate Geometry; Arihant.
2. Shantinarayan; Analytical Solid Geometry; S. Chand.
3. J.G. Chakraborty & P.R. Ghosh, Advanced Analytical Geometry, U.N. Dhur & Sons Pvt. Ltd.
4. R.M. Khan, Analytical Geometry of two and three dimensions and vector analysis, New central book agency (P) Ltd., Kolkata.
5. Arup Mukherjee and Naba Kumar Bej, Analytical Geometry of Two and Three dimensions (Advanced level), Books & Allied Pvt. Ltd.
6. Shantinarayan and P K Mittal, A Text Book of Vector Analysis, S. Chand.
7. J.G. Chakraborty & P.R. Ghosh, Vector Analysis, U.N. Dhur & Sons Pvt. Ltd.
8. Robert J.T. Bell, An Elementary Treatise on Coordinate Geometry of Three Dimensions, McMilan & Co. Ltd., London.
9. S. Lipschutz, D. Spellman, M.R. Speigel, Vector Analysis, Schaum's outline series.
10. J. Marsden and Tromba, Vector Calculus, McGraw Hill.
11. Ghosh & Maity, Vector Analysis, New Central Book Agency (P) Ltd.
12. Dipak Kumar Ghosh; Introduction to Partial Differential Equation and Laplace Transform; NCBA.
13. I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, New York
14. F.H. Miller, Partial Differential Equations, John Wiley and Sons.

COURSE OBJECTIVES:

To impart details knowledge of Three Dimensional Geometry, Vector Calculus and Partial Differential Equations with its solution techniques

COURSE OUTCOMES:

CO-1 Understanding the concept of Three-dimensional space and it's geometry

CO-2 Understanding the geometrical characteristics of Sphere, Cone, Cylinder and the Generators of the Quadrics

CO-3 Concept of Central Conicoids like Ellipsoid, Hyperboloids of One or Two Sheets

CO-4 Familiarize with Generating lines with Ruled and Skew Surfaces

CO-5 Understanding the concepts of Transformation of co-ordinate axes in three dimensions and reduction of Second degree equations to its canonical form

CO-6 Concept of Vector Calculus, Differentiation and Integration of vector-valued functions

CO-7 Idea of Gradient, Divergence & Curl of Vectors and their properties

CO-8 Understanding of Line integral. Surface integral and Volume integral of vector functions; applications of Green's theorem and Stokes' theorem

CO-9 Understanding the basic concepts of Partial Differential Equations

CO-10 Familiarize with Formation and Solution techniques of linear and non-linear Partial Differential Equations

SEMESTER 5

Paper: Major–6 **Code: BMTMMAJ06T**

Title: Dynamics of Particles and System of Particles

Syllabus: **Credit: 6**

Unit -1: Dynamics of a Particle [Credit: 4, 60 L]

Kinematics

1. Expressions for velocity & acceleration for

(i) Motion in a straight line;

(ii) Motion in a plane;

(a) Cartesian co-ordinates, (b) Polar co-ordinates, (c) Intrinsic co-ordinates

Kinetics

2. Newton's laws of motion, Equation of motion of a particle moving under the action of given external forces.

(a) Motion of a particle in a straight line under the action of forces μx^n, $n = 0, \pm 1, n = -2$ ($\mu > 0$ or < 0) with physical interpretation,

(b) Simple harmonic motion and elementary problems,

(c) The S.H.M. of a particle attached to one end of an elastic string, the other end being fixed,

(d) Harmonic oscillator, effect of a disturbing force, linearly damped harmonic motion and forced oscillation with or without damping,

(e) Vertical motion under gravity when resistance varies as some integral power of velocity, terminal velocity.

(f) Works, power and energy, Conservation laws: conservation of linear momentum, angular momentum and total energy for conservative system of forces.

3. Impulse of force, Impulsive forces, change of momentum under impulsive forces, Examples, Collision of two smooth elastic bodies, Newton's experimental law of impact, Direct and oblique impacts of (i) Sphere on a fixed horizontal plane, (ii) Two smooth spheres, Loss of Kinetic Energy and Impulse

4. Motion in plane/ two dimensions:

(a) Motion of a particle moving on a plane referred to a set of rectangular axes, Angular velocity and acceleration, Circular motion,

(b) Trajectories in a medium with the

(i) Motion of a projectile under gravity in free space;

(ii) Motion of a projectile under gravity with air resistance proportional to velocity, square of the velocity;

(c) Motion of a particle moving on a plane referred to polar co-ordinate system, radial and transverse Accelerations.

(d) Central forces and central Orbits: Motion under a central force, basic properties and differential equation of the path under given forces and velocity of projection, Apses, Time to describe a given arc of an orbit, Law of force when the center of force and the central orbit are known. Special study of the following problems; to find the central force for the following orbits:

(i) A central conic with the force directed towards the focus;

(ii) Equiangular spiral under a force to the pole;

(iii) Circular orbit under a force towards a point on the circumference.

(e) To determine the nature of the orbit and of motion for different velocity of projection under a force per unit mass equal to –

(i) $\mu / (\text{dist})^2$ towards a fixed point ;

(ii) under a repulsive force $\mu / (\text{dist})^2$ away from a fixed point .

(f) Circular orbit under any law of force $\mu f(r)$ with the centre of the circle as the centre of force, stability analysis of a circular orbit under a force $\mu f(r)$ towards the center. Particular case $\mu f(r) = 1/r^n$.

(g) Kepler's laws of planetary motion from the equation of motion of a central orbit under inverse square law, Modification of Kepler's third law from consideration of motion of a system of two particles under mutual attractions according to Newton's law of gravitational attraction, Escape velocity.

(h) Constrained Motion: Motion of a particle along a smooth curve, Examples of motion under gravity along a smooth vertical circular curve, smooth vertical cycloidal arc (cycloidal pendulum), Motion of a particle along a rough curve (circle, cycloid) & in a resisting medium.

Unit -2: Dynamics of System of Particles **[Credit: 2, 30 L]**

Fundamental concepts: Centre of mass, linear momentum, angular momentum, kinetic energy, work done by a field of force, conservative system of forces – potential and potential energy, internal potential energy, total energy.

The following results to be deduced in connection with the motion of system of particles:

(i) Centre of mass moves as if the total external force were acting on the entire mass of the system concentrated at the centre of mass (examples of exploding shell, jet and rocket propulsion).

(ii) The total angular momentum of the system about a point is the angular momentum of the system concentrated at the centre of mass, plus the angular momentum for motion about the center.

(iii) Similar theorem as in (ii) for kinetic energy.

An idea of constraints that may limit the motion of the system, definition of rigid bodies, D'Alembert's principle, principle of virtual work for equilibrium of a connected system.

Reading References:

1. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.
2. Terence Tao, Analysis II, Hindustan Book Agency, 2006.
3. Ganguly and Saha; Analytical Dynamics of Particles; New Central Book Agency.
4. Dutta and Jana; Dynamics of a Particle; Shreedhar Prakashani.
5. A. S. Ramsey; Dynamics (Part 1); CBS Publisher.
6. J. L. Synge & B. A. Griffith ; Principles of Mechanics; McGraw Hill Book Company Inc.
7. Chorlton; A Text Book of Dynamics; D. Van Nostrand Company Ltd.
8. Mollah, S. A., Advanced Dynamics of Particles, Books & Allied.
9. H. Goldstein; Classical Mechanics; Addison-Wesley.
10. Ghosh, Chakraborty; Advanced Analytical Dynamics; U.N. Dhur Publishing House.
11. R. G. Takwale, P. S. Puranik; Introduction to Classical Mechanics; McGraw Hill Education.

COURSE OBJECTIVES:

To impart details knowledge of Dynamics of Particles and System of Particles

COURSE OUTCOMES:

CO-1 Understanding the concept of motion of a particle in a straight line in resisting and non-resisting Medium

CO-2 Familiarize with Simple Harmonic Motion and its applications

CO-3 Understanding the concept of Impulsive Forces and its application in collision of elastic bodies

CO-4 Understanding the concept of motion of a particle in two dimensional Cartesian plane

CO-5 Understanding the concept of motion of a particle in two dimensional polar plane and its application in the study of Central Orbits and Planetary Motion

CO-6 Conceptualize the idea of Constrained Motion

CO-7 Understanding of the motion of System of Particles

CO-8 Concept of Centre of mass, linear momentum, angular momentum, kinetic energy, work done by a field of force in connection with motion of system of particles

Paper: Major–7 **Code: BMTMMAJ07T**

Title: Real Analysis - II

Syllabus: **Credit: 6**

Real Analysis-II **[Credit: 5, 75 L]**

(a) Compactness in $\mathbb{R}$: Concepts of open cover of a set. Compact set in IR, Heine-Borel theorem (Proof not required).

(b) Functions of bounded variation (BV): Definition and examples. Monotone function is of BV. If f is on BV on $[a,b]$ then f is bounded on $[a,b]$. Examples of functions of BV which are not continuous and continuous functions not of BV. Bounded variation functions and their properties. Necessary and sufficient condition for a function f to be of BV on [a,b] is that f can be written as the difference of two monotonic increasing functions on$[a,b]$.

(c) Riemann integration: Partition and refinement of partition of a closed and bounded interval. Upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions. Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals. Antiderivative (primitive or indefinite integral). Fundamental theorem of Integral Calculus. First Mean Value theorem of integral calculus. Statement of second mean value theorems of integrals calculus (both Bonnet's and Weierstrass' form) and simple problems.

(d) Riemann-Stieltjes integral: Upper and lower Riemann-Stieltjes integral, Rectifiable Curves. Change of variable in a Riemann-Stieltjes integral, Reduction to Riemann integral, necessary as well as sufficient conditions for existence of Riemann-Stieltjes integrals.

(e) Improper integrals: Types of improper integrals with examples, convergence of improper integrals with examples. Convergence of Beta and Gamma functions.

(f) Sequence of Functions: Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.

(g) Series of functions: Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

(h) Fourier series: Definition of Fourier coefficients and series, Reimann-Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series.

(i) Power series: Radius of convergence. Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem (statement only).

Reading References:

1. S.K. Mapa; Introduction to Real analysis; Levant.
2. G.B. Thomas and R.L. Finney; Calculus, 9th Ed.; Pearson Education, Delhi; 2005.
3. Tom M. Apostol; Mathematical Analysis; Narosa Publishing House.
4. Courant and John; Introduction to Calculus and Analysis, Vol II; Springer.
5. W. Rudin; Principles of Mathematical Analysis; Tata McGraw-Hill.
6. S.N. Mukhopadhyay, S. Mitra; Mathematical Analysis, Vol-II; U.N Dhur & Sons Pvt. Ltd; 2014.
7. S.C. Malik & Savita Arora; Mathematical Analysis; New Age International (P) Limited.
8. Steen, L., Seebach, J.; Counter Examples in Topology; Holt, Reinhart and Winston, New York.
9. Hocking, J., Young, G.; Topology; Addison-Wesley Reading; 1961.
10. Kelley, J.L.; General Topology; Van Nostrand Reinhold Co., New York; 1995.
11. Simmons, G.F.; Introduction to Topology and Modern Analysis; McGraw Hill, 1963.
12. Dugundji, J.; Topology; Allyn and Bacon, 1966.
13. Munkres, J.R.; Topology: A First Course; Prentice Hall of India Pvt. Ltd., New Delhi; 2000.

COURSE OBJECTIVES:

To impart details knowledge of Riemann integration, Riemann-Stieltjes integral, functions of Bounded Variations, Improper Integral, Sequence & Series of Functions, Power Series & Fourier Series.

COURSE OUTCOMES:

CO-1 Upon successful completion, the students will be familiar with open cover and functions of bounded variation in $\mathbb{R}$

CO-2 Objective of this course is the introduction of some new type of integrations viz. Riemann Integrals, Riemann-Stieltjes integrals

CO-3 After successful completion, Students will have the clear knowledge on Riemann integration and their properties and also students will be able to integrate functions in the sense of Riemann

CO-4 Upon successful completion of the course students will determine the type of improper integration and will develop the capacity to examine the convergence of the improper integral

CO-5 After successful completion of the course the students will acquire the ability to solve the problems in sequence of functions, series of functions and Fourier series. Also they will be able to find the radius of convergence of the power series and their properties in the relevant field

CO-6 This course offers to the students, the basic ideas of point set topology and rigorous understanding of fundamental concepts in Mathematics. This will be helpful to the students in understanding pure mathematics and in research

SEMESTER 6

Paper: Major–8 **Code: BMTMMAJ08T**

Title: Linear Programming Problems and Game Theory

Syllabus: **Credit: 6**

Unit -1: Linear Programming Problems **[Credit: 4, 60 L]**

- Canonical & Standard form of L.P.P, Basic solutions, feasible, basic feasible & optimal solutions, Reduction of a feasible solution to basic feasible solution, Hyperplanes and Hyperspheres, Convex sets and their properties, convex functions, Extreme points, Convex feasible region, Convex polyhedron, Polytope, Graphical solution of L. P.P.
- Fundamental theorems of L.P.P., Improved basic feasible solutions, Bounded and 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. Degeneracy in L.P.P. and its resolution.
- Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method.
- Dual Simplex method, modified dual simplex method, and revised simplex method.
- Transportation Problem (T.P.): Matrix form of T.P., the transportation table, Initial basic feasible solutions (different methods like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Loops in T.P. table and their properties, Optimal solutions, Degeneracy in T.P., Unbalanced T.P.
- Assignment Problem, Mathematical justification for optimal criterion, optimal solution by Hungarian Method, Travelling Salesman Problem

Unit -2: Game Theory **[Credit: 2, 30 L]**

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

Reading References:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
5. Ghosh & Chakraborty, An Introduction to Linear Programming & Game Theory, Maulik Libray
6. Karak, P. M., Linear Programming with Game Theory, New Central Book Agency
7. Sharma, J. K., Operations Research – Theory and Applications
8. Swarup, Gupta & Man Mohan – Operations Research

COURSE OBJECTIVES:

Familiar with Optimization Problems, Linear Programming Problem and its solution techniques; an introductory knowledge of Game Theory and solution of Two Person Zero Sum Game Problems

COURSE OUTCOMES:

CO-1 Introduction of the Optmization Problems and Formation of Linear Programming Problem

CO-2 Familiarize with the basic theorems of LPP and concepts of Convex Sets, Convex Functions, Feasible and Basic Feasible Solutions of LPP

CO-3 Understanding the idea of Simplex Algorithm as a Solution technique of LPP and Duality Theory

CO-4 Familiarize with the concept of Degeneracy in LPP and its resolution

CO-5 Familiarize with Dual Simplex algorithim for solving LPP

CO-6 Understanding of Transportation and Assignment Problems with their solution techniques

CO-7 Introduction of the concept of Game Theory, Two-Person-Zero-Sum Game

CO-8 Familiarize with different solution techniques of Game Problems and also solving Game Problems using LPP

Paper: Major–9 **Code: BMTMMAJ09T**

Title: Probability and Statistics

Syllabus: **Credit: 6**

Unit -1: Probability **[Credit: 4, 60 L]**

- Sample space and Axiomatic definition of probability, Compound experiment.
- One and two dimensional random variables (Discrete and Continuous): Distribution function and its basic properties, Probability density function, Marginal distribution and density function, Conditional density function.
- Transformation of one and two dimensional random variables.
- Mathematical expectation, Median, Mode, Moments, Variance.
- Expectation for two dimensional case, Moments, Covariance, Correlation coefficient and its properties, Addition and multiplication rule for expectation and variance, Independent random variables. Moment generating function, Characteristic function.
- Conditional expectation and regression – Least square regression lines and basic properties.
- Some important distributions: Binomial, Poisson, Uniform, exponential, Cauchy, Normal, Gamma, Beta and their basic property.
- Tchebycheff's inequality, Convergence in probability, Bernoulli's limit theorem, Central limit theorem.
- Approximations – Binomial to Poisson, Central limit theorem (statement only). Binomial to Normal (De Moivre-Laplace limit theorem)

Unit -2: Statistics **[Credit: 2, 30 L]**

- Concept of statistics, Sampling distribution of sample mean for finite population with examples.
- Sampling distribution for infinite population, Exact sampling distribution-for mean of normal population, Chi-square and t-distribution.
- Point Estimation – consistent, unbiased, MVUE. Method of maximum likelihood and application to different population.
- Interval estimation- Method of finding confidence interval- Application to normal population
- Testing of hypothesis: Critical region, Type-I and Type-II error, Power of test, Large sample test related to Binomial proportion, Chi-square test on multinominal distribution, Exact tests for mean and variance of unvariate Normal distribution

Reading References:

1. A.P. Baisnab and M. Jas; Elements of Probability and Statistics ; Tata McGraw Hill Co. Ltd
2. Amritava Gupta; Groundwork of Mathematical Probability and Statistics; Academic Publishers.
3. Gun, Gupta, Dasgupta; Fundamentals of Statistics; World Press.
4. S.C. Gupta, V. K. Kapoor; Fundamentals of Mathematical Statistics; S. Chand & Sons.
5. N.G. Das; Statistical Methods; M Das & Co.

COURSE OBJECTIVES:

Familiarize with Probability Theory, Probability Density Function and Probability Distribution Function.

To develop the concept of Mathematical Expectations of Single variable & two variables

To develop the concept of Statistics, Sampling Distribution and Estimation

COURSE OUTCOMES:

CO-1 Acquire in depth knowledge of Probability, probability density function, probability distribution function, moment generating functions for discrete and continuous variables

CO-2 Understanding the joint cumulative distribution function, probability density function and expectations

CO-3 To develop the concept of statistical population and random sample, sampling distribution sample mean with χ^2 and t distribution

CO-4 Familiarize with the concept of Testing of hypothesis based on z, χ^2 and t distributions

Paper: Major–10 **Code: BMTMMAJ10T**

Title: Numerical Methods & Computer Programming in C

Syllabus: **Credit: 6**

Unit -1: Numerical Methods **[Credit: 4, 60 L]**

- Approximation of numbers, decimal places, significant figures, Round off Errors: Relative, Absolute and Percentage. Truncation, Inherrent.
- Solution of Transcendental and Polynomial equations using Bisection method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Geometrical interpretation, convergency conditions, Rate of convergence of these methods.
- System of linear algebraic equations: Gaussian Elimination, Gauss Seidel method and their convergence analysis.
- **Interpolation:** Finite difference operators, Lagrange's interpolation formula, Newton's forward and backward interpolation formula, divided difference, Newton's general interpolation formula, Interpolating Errors.
- **Numerical Integration:** Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Inherent errors, degree of precision.
- **Ordinary Differential Equations:** The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four (Proof of order four is not required).

Unit -2: Computer Programming in C **[Credit: 2, 30 L]**

- Computer Languages: Machine language, Assembly language, computer-high level languages, Compiler, Interpreter, Operating system, Source programs and objects programs.
- Binary number system, Conversions and arithmetic operation, Representation for Integers and Real numbers, Fixed and floating point.
- Introduction to C programming: Basic structures, Character set, Keywords, Identifiers, Constants, Variable-type declaration
- Operators: Arithmetic, Relational, Logical, assignment, Increment, decrement, Conditional. Operator precedence and associativity, Arithmetic expression,
- Statement: Input and Output, Define, Assignment, User define, Decision making (branching and looping) – Simple and nested IF, IF – ELSE, LADDER, SWITCH, GOTO, DO, WHILE – DO, FOR, BREAK AND CONTINUE Statements. Arrays- one and two dimensions, user defined functions.
- Statistical and other simple programming:
  (a) To find mean, median, mode, standard deviation
  (b) Ascending, descending ordering of numbers
  (c) Finite sum of a series
  (d) Fibonacci numbers
  (e) Checking of prime numbers
  (f) Factorial of a number
  (g) Solution of a quadratic equation
  (h) L.C.M. & G.C.D. of two positive integers.
  (i) Conversion of temperature from Fahrenheit to Centigrade and vice-versa.
  (j) Area of a triangle
  (k) To find simple and compound interest.

Reading References:

1. S.A. Mollah; Numerical Analysis and Computational Procedures.
2. Yashavant Kanetkar; Let Us C; BPB Publications.
3. K.E. Atkinson; An Introduction to Numerical Analysis; John Wiley and Sons; 1978.
4. C. Xavier; C Language and Numerical Methods; New Age Intl (P) Ltd. Pub.
5. B.S. Gottfried; Programming with C; TMH.
6. E. Balaguruswamy; Programming in ANSI C; TMH.
7. N. Datta; Computer Programming and Numerical Analysis-An Integrated Approach (Revised edition with C); Universities Press.

COURSE OBJECTIVES:

To develop numerical mathematical modeling using Interpolation, numerical solution technique to solve algebraic and transcendental equations, numerical quadrature
Familiarize with C language and using C Programming Language numerical solution of basic mathematical properties

COURSE OUTCOMES:

CO-1 Understanding the concept of Convergence, Errors, Rounding-off, Truncation in Numerical Methods

CO-2 Familiarize with Interpolation for equi-spaced and un-equi-spaced arguments

CO-3 Understanding different solution methods for finding root of algebraic and transcendental equations with their geometrical interpretations and convergence conditions

CO-4 Familiarize with solution methods of system of linear equations

CO-5 Concept of Numerical Integration, idea of Newton-Cotes' quadrature formula, Trapezoidal and Simpson's formula

CO-6 Understanding the concept of numerical methods for solving First Order Ordinary Differential Equations using Euler method and Runge-Kutta method of order 2 and 4

CO-7 Understand the basics of computer programming in C, including Boolean algebra and binary number system

CO-8 Able to write C programs using fundamental programming structures such as variables, operators, conditional statements (IF, IF-ELSE, LADDER, SWITCH), loops (DO, WHILE-DO, FOR), and arrays (one and two dimensions)

SEMESTER 7

Paper: Major–11 **Code: BMTMMAJ11T**

Title: Metric Space & Complex Analysis

Syllabus: **Credit: 6**

Unit-1: Metric Spaces **[Credit: 3, 45 L]**

- Metric, examples of standard metric spaces including Euclidean and Discrete metrics; open ball, closed ball, open sets; metric topology; closed sets, limit points and their fundamental properties; interior, closure and boundary of subsets and their interrelation; denseness; separable and second countable metric spaces and their relationship.
- **Continuity:** Definition of continuous functions, algebra of real/complex valued continuous functions, distance between a point and a subset, distance between two subsets, Homeomorphism (definitions with simple examples)
- **Sequence and completeness:** Sequence, subsequence and their convergence; Cauchy sequence, Cauchy's General Principle of convergence, Cauchy's Limit Theorems. Completeness, completeness of$\mathbb{R}^n$; Cantor's theorem concerning completeness, Definition of completion of a metric space, construction of the real as the completion of the incomplete metric space of the rational with usual distance (proof not required). Continuity preserves convergence.
- **Compactness**: Sequential compactness, Heine-Borel theorem in R. Finite intersection property, continuous functions on compact sets.
- **Connectedness:** Connected subsets of the real line$\mathbb{R}$, open connected subsets in$\mathbb{R}^2$, components; components of open sets in $\mathbb{R}$ and$\mathbb{R}^2$; Structure of open set in $\mathbb{R}$, continuity and connectedness; Intermediate value theorem.

Unit-2: Complex Analysis **[Credit: 3, 30 L]**

- Introduction of complex number as ordered pair of real numbers, geometric interpretation, metric structure of the complex plane **C**, regions in **C.** Stereographic projection and extended complex plane $\mathbf{C}_\infty$ and circles in $\mathbf{C}_\infty$
- Limits, Continuity and differentiability of a function of complex variable, sufficient condition for differentiability of a complex function, Analytic functions and Cauchy-Riemann equation, harmonic functions, Conjugate harmonic functions, Relation between analytic function and harmonic function.
- Transformation (mapping), Concept of Conformal mapping, Bilinear or M*ó*bius transformation and its geometrical meaning, fixed points and circle preserving character of M*ó*bius transformation.
- Power series: Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Analytic functions represented by power series. Uniqueness of power series.
- Contours, complex integration along a contour and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem (statement only) and its consequences, Cauchy integral formula.

Reading References:

1. Satish Shirali and Harikishan L. Vasudeva; Metric Spaces; Springer Verlag, London; 2006.
2. S. Kumaresan; Topology of Metric Spaces, 2nd Ed.; Narosa Publishing House; 2011.
3. J. Sengupta; Metric Spaces; U.N. Dhur & Sons Private Limited.
4. P. K. Jain and K. Ahmad; Metric Spaces; Narosa Publishing House.
5. G.F. Simmons; Introduction to Topology and Modern Analysis; McGraw-Hill; 2004.
6. James Ward Brown and Ruel V. Churchill; Complex Variables and Applications, 8th Ed.; McGraw – Hill International Edition; 2009.
7. J.B. Conway; Functions of one Complex Variable, 2nd Ed.; Undergraduate Texts in Mathematics; Springer-Verlag New York, Inc.
8. S. Ponnusamy; Foundations of complex analysis; Narosa Publishing House.
9. E.M.Stein and R. Shakrachi; Complex Analysis, 2nd Ed; Princeton University Press.
10. Joseph Bak and Donald J. Newman; Complex Analysis, 2nd Ed.; Undergraduate Texts in Mathematics; Springer-Verlag New York, Inc., NewYork; 1997.
11. R. Roopkumar; Complex Analysis; Pearson.

COURSE OBJECTIVES:

To understand the fundamental concepts of metric spaces, including open and closed sets, completeness and connectedness in metric spaces and their significance in analysis

To explore properties of analytical functions, contour integration, Cauchy integral formula and their applications in evaluating integrals and solving real world problems

COURSE OUTCOMES:

CO-1 Idea of Metric Spaces with some standard examples

CO-2 Familiarize with Continuity and Homeomorphisms in Metric Spaces

CO-3 Detailed study of Compactness, Connectedness and Completeness of Metric Spaces

CO-4 Developing problem-solving skills using key theorems like Heine-Boral theorem, Intersection theorem

CO-5 Understanding the Stereographic projection of complex number and extended complex plane

CO-6 Understanding the Concept of Limit, Continuity and Differentiability of a complex function and Cauchy-Riemann equation

CO-7 Understanding the Concept of Conformal mappings and Bilinear transformations

Paper: Major–12 **Code: BMTMMAJ12T**

Title: Abstract Algebra-II & Linear Algebra-II

Syllabus: **Credit: 6**

Unit -1: Abstract Algebra-II **[Credit: 3, 45 L]**

- Direct product of a finite number of groups, Group Actions, Orbit, Stabilizer, Class Equation, Cauchy's Theorem, Sylow Theorems.
- Prime and Maximal ideal. Ring homomorphism, Isomorphism, 1st, 2nd and 3rd Isomorphism Theorems (Statements only).
- Polynomial rings over commutative rings, Irreducibility of polynomials, Division Algorithm, Principal ideal domain, Euclidean domain.
- **Field Extensions:** Field extension, finite extension, simple extension, algebraic and transcendental extension and their characterizations. Splitting field, algebraic closure and algebraically closed field. Separable and normal extensions. Construction with straightedge and compass, finite fields and their properties, Galois group, Galois theory, Solvability by radicals, insolvability of the general equations of degree five (or more) by radicals.

Unit -2: Linear Algebra-II **[Credit: 3, 45 L]**

- Introduction to linear transformations, algebra of linear transformation, rank and nullity of a linear transformation, matrix representation of a linear transformation.
- Dual Spaces, Dual Basis, Double Dual, Transpose of a linear transformation.
- Eigen Value, Eigen Vector and Eigen space of linear operator, diagonalizability, Cayley-Hamilton theorem for linear operator (Statement only), minimal polynomial for linear operator.
- Bilinear Form, Real Quadratic Form involving three variables, Reduction to Normal Form (Statements of relevant theorems and applications).
- Inner product spaces and norms, orthogonal & orthonormal set, triangular inequality, Schwartz inequality, Parallelogram law, Gram-Schmidt orthogonalization process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator.

Reading References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. Gilbert, Linear Algebra and its Applications, Thomson, 2007.
6. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill Education-Europe.
8. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
9. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
10. S. K. Mapa, Higher Algebra (Abstract and Linear), Levant Books.
11. M. K. Sen, S. Ghosh, P Mukhopadhyay, S. Maity, Topics in Abstract Algebra, Universities Press.

COURSE OBJECTIVES:

To develop understanding of direct product of groups and exploring ring and field theory, focusing on homomorphisms, maximal and prime ideals and polynomial rings.
To study linear transformations, matrix representations, eigen values and eigen vectors and explore inner product spaces, orthogonality and diagonalization techniques for real world applications.

COURSE OUTCOMES:

CO-1 Get concepts of direct product of finite number of group and group action etc.
CO-2 Familiarize with ideal and isomorphism of rings and polynomial ring etc.; use diverse property of field extension in various areas.
CO-3 Compute the Galois group for several classical situations.
CO-4 Understanding the Linear Transformation and Matrix representation of a Linear Transformation.
CO-5 Concept of Eigen values and Eigen vectors of a matrix and Diagonalization of Matrices of order 2 and 3.
CO-6 Understanding the concept of Elementary of Inner Product Spaces and Norms.

Paper: Major–13 **Code: BMTMMAJ13S**

Title: Computer Aided Numerical Practical in C (P)

Syllabus: **Credit: 6**

Unit -1: Problem-I: Known Problems **[Credit: 3, 90 L]**

List of Problems for C Programming:

1. Finding a real Root of an equation by,
   (a) Fixed point iteration.
   (b) Newton-Rapson's method.
2. Interpolation (Taking at least six points) by,
   (a) Lagrange's formula.
   (b) Newton's Forward Formula.
   (c) Newton's Backward Formula.
3. Integration by
   (a) Trapezoidal rule.
   (b) Simpson's $1/3^{rd}$ rule (taking at least 50 sub-intervals).
4. Solution of a 1storder ordinary differential equation by
   (a) Modified Euler's Method.
   (b) Fourth-order R. K. Method (taking at least four steps).

Unit -2: Problem-II: Unknown Problems **[Credit: 2, 60 L]**

Statistical and other simple programming like
(a) To find mean, median, mode, standard deviation
(b) Ascending, descending ordering of numbers
(c) Finite sum of a series
(d) Fibonacci numbers
(e) Checking of prime numbers
(f) Factorial of a number
(g) Solution of a quadratic equation
(h) L.C.M. & G.C.D. of two positive integers etc.

Unit -3: Sessional & Viva-voce **[Credit: 1]**

Reading References:

1. S.A. Mollah; Numerical Analysis and Computational Procedures.
2. Yashavant Kanetkar; Let Us C; BPB Publications.
3. K.E. Atkinson; An Introduction to Numerical Analysis; John Wiley and Sons; 1978.
4. C. Xavier; C Language and Numerical Methods; New Age Intl (P) Ltd. Pub.
5. B.S. Gottfried; Programming with C; TMH.
6. E. Balaguruswamy; Programming in ANSI C; TMH.
7. N. Datta; Computer Programming and Numerical Analysis-An Integrated Approach (Revised edition with C); Universities Press.

COURSE OBJECTIVES:

To develop hands on experience to compile programs written in C language for solving different numerical problems using C compiler in Desktop Computers

COURSE OUTCOMES:

CO-1 Familiarize with hand-on experience of using computers for solving numerical problems

CO-2 Understand to write the programs using C language for solving interpolation problem, finding root of an equation, solving numerical integration and differential equations

SEMESTER 8

Paper: Major–14 **Code: BMTMMAJ14T**

Title: General Topology

Syllabus: **Credit: 4**

General Topology **[Credit: 4, 60 L]**

- Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor's Theorem. Cardinal Numbers and Cardinal Arithmetic. Continuum Hypothesis, Zorns Lemma, Axiom of Choice. Well-Ordered Sets, Hausdorff's Maximal Principle. Ordinal Numbers.
- **Fundamentals of Topological Spaces:** Topological spaces. Bases and sub-bases. Closure & interior; exterior, boundary, accumulation points, derived sets, dense set, G_δ and F_σ sets. Neighbourhood system. Order Topology. Discrete space.
- **Subspace Topology:** Subspace topology and its properties; Alternative way of defining a topology using Kuratowski closure operator, interior operator and neighbourhood systems; Continuous Functions, Open maps, Closed maps and Homeomorphisms, topological property, metric topology.
- **Product Spaces:** Product and box topology, Projection maps. Quotient topology. Tychonoff theorem. Separation axioms, Countability axioms and Connectedness in product spaces.
- **Countability Axioms:** First and Second countability axioms, Separability and Lindeloffness. Characterizations of accumulation points, closed sets, open sets in a First countable space w.r.t. sequences. Heine's continuity criterion.
- **Separation Axioms:** T_i spaces (i = 0, 1, 2, 3, 3½, 4, 5), their characterizations and basic properties. Urysohn's lemma and Tieze's extension theorem (statement only) and their applications.
- **Compactness:** Compactness and its basic properties, Alexander sub-base theorem, Continuous functions and compact sets. Compactness of$\mathbb{R}$. Sequential compactness, BW Compactness and countable compactness. Lebesgue Number. Local compactness, compactness in metric space, totally bounded space, Arzela-Ascoli theorem.
- **Connectedness:** Connected and disconnected spaces, Path Connected Spaces, Connected Sets in$\mathbb{R}$, $\mathbb{R}^n (n > 1)$, Local connectedness, Components and Path Components, Totally disconnected.

Reading References:

1. John L. Kelley; General Topology; D. Van Nostrand Company, Inc.; 1995.
2. Stephen Willard; General Topology; Addison Wesley Publishing Company; 1970.
3. James Dugundji; Topology; Allyn and Bacon, Inc.; 1978.
4. James R. Munkres, Topology: A first course; Prentice Hall, India; 1974.
5. G.F. Simmons; Introduction to Topology and Modern Analysis; McGraw Hill.
6. K.D. Joshi; Introduction to General Topology; Wiley Eastern Ltd.
7. Engelking; General Topology; Polish Scientific Publishers, Warszawa.
8. L.A. Steen and J.A. Seebach; Counterexamples in Topology; Dover Publication, Inc. New York.
9. B.C. Chatterjee, M. R. Adhikari and S. Ganguly; A text book of Topology; Asian Books; 2002.
10. W.J. Thron; Topological Structures; Holt, Rinehart and Winston, Inc., New York, 1966.

COURSE OBJECTIVES:

The course aims to introduce fundamental concepts of topological spaces, open and closed sets, continuity and different types of topologies. It focuses on key properties such as compactness, connectedness and separability, along with important theorems like Urysohn's lemma and Tychonoff's theorem. Students will develop problem solving skills and apply topological concepts in advanced mathematics and related fields.

COURSE OUTCOMES:

CO-1 Understanding the terms, definitions and theorems related to topology

CO-2 Imparting knowledge and understanding the concepts of open and closed sets, interior, closure and boundary.

CO-3 Create new topological spaces by using subspace, product and quotient topologies

CO-4 Use continuous functions and homeomorphisms to understand structure of topological spaces

CO-5 Apply theoretical concepts in topology to understand real world application

Paper: Major–15 **Code: BMTMMAJ15T**

Title: Integral Transforms & Integral Equations

Syllabus: **Credit: 4**

Unit -1: Laplace Transform **[Credit: 1, 15 L]**

Definition and properties of Laplace transforms, Sufficient conditions for the existence of Laplace Transform (proof not required), Laplace Transform of some elementary functions, Laplace Transforms of the derivatives, integrals, and derivatives, integrals of Laplace transform. Initial and final value theorems, Convolution theorems, Inverse of Laplace Transform, Application to Ordinary differential equations

Unit-2: Fourier Transform **[Credit: 1, 15 L]**

Fourier integral theorem, Definition and Properties, Fourier transform of some elementary functions, Fourier transform of the derivative, Derivative of Fourier transform, Fourier sine and cosine transforms, Inverse of Fourier transform, Convolution, Properties of convolution functions, Convolution theorem and applications

Unit -3: Integral Equations **[Credit: 2, 30 L]**

Linear Integral Equations of 1^{st} and 2^{nd} kinds- Fredholm and Volterra types, Relation between integral equations and initial boundary value problems, Existence and uniqueness of continuous solutions of Fredholm and Volterra's integral equations of 2^{nd} kind, Iterated Kernels, Reciprocal Kernels, Solution by the method of successive approximations, Solution by Resolvent kernel method and iterated kernel method. Volterra's solution of Fredholm's integral equations. Reduction of boundary value problem of an ordinary differential equation to an integral equation and vice-versa, symmetric Kernel, Hilbert-Schmidt method.

Reading References:

1. Sneddon, I. N., Fourier Transform, McGraw Hill.
2. Miller, F. H., Partial Differential Equations, John Wiley and Sons
3. Sneddon, I.N., Use of Integral Transforms, McGraw-Hill Pub.
4. Tranter, C. J., Integral Transforms
5. Tricomi, Integral Equations
6. Andrews, L.C., Shivamoggi, B., Integral Transforms for Engineers, PHI.
7. Debnath, L., Bhatta,D., Integral Transforms and Their Applications, CRC Press, 2007.
8. G. C. Gorain, Laplace Transformations, Narosa Publishing House, New Delhi.
9. Lovitt, Linear Integral Equations

COURSE OBJECTIVES

To provide a fundamental understanding of integral transform, including Laplace and Fourier transforms and their role in solving differential equations
To introduce integral equations, focusing on Volterra and Fredholm equations and their solutions using various analytical techniques

COURSE OUTCOMES:

CO-1 Understanding the basic concepts of Laplace Transform and the idea Laplace Transform of Some Elementary Functions & Derivatives

CO-2 Understanding the Convolution Theorem & Inverse of Laplace Transform and applications

CO-3 Understanding the basic concepts of Fourier Transform and the idea Fourier Transform of Some Elementary Functions & Derivatives

CO-4 Understanding the Convolution Theorem & Inverse of Fourier Transform and applications to ordinary and partial differential equations

CO-5 Familiarize with Fredholm and Volterra types of integral equations and their solutions

CO-6 Understanding solution of integral equations by Resolvent kernel method and iterated kernel method

CO-7 Acquainted with the reduction of boundary value problems of ordinary differential equations with to integral equations and vice versa

Paper: Major–16 **Code: BMTMMAJ16T**

Title: Elementary Differential Geometry

Syllabus: **Credit: 4**

Elementary Differential Geometry [Credit: 4, 60 L]

Tensors:

- Definition of a tensor as a generalization of vectors in a vector space V. Tensor and their transformation laws, Covariant and contravariant vectors to Covariant and contravariant tensors, Tensor algebra, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, Symmetric and skew-Symmetric tensors, fundamental metric tensor, Riemannian space, Christoffel symbols and their transformation law, Covariant differentiation of vector and tensor.

- **Curves in Space:** level curves and parametrized curves in R_n, arc length of curve, reparametrization, plane curves and space curves and their curvature and properties and tangent and normal at a point on the curves. Torsion of space curves, Helix, Serret- Frenet formulae for curves in space. Simple closed curves with periods. Isoperimetric inequality, Intrinsic differentiation and Curvilinear coordinates Geodesic.
- **Surfaces:** Surfaces and its parametric representation, Regular surfaces and example. Tangent, normal and orientability of surfaces. Smooth functions on a surface, Differential of a smooth function defined on a surface. Angle between two curves on a surface, The first and second fundamental form of surface, Geodesic curvature, normal curvature and principal curvature of a surface curve, Meusnier's theorem, The third fundamental form, Gaussian and mean curvature, Riemann curvature tensor and Ricci tensor. Riemannian metric, Isometry of surfaces, Developable surfaces, Weingarten formula, Equation of Gauss and Codazzi.

Reading References:

1. M. C. Chaki; Tensor Analysis; The Calcutta Publishers.
2. B. Spain, Tensor Calculus: A Concise Course, Dover Publication, 2003.
3. U.C. De, A. A. Shaikh, J. Sengupta; Tensor Calculus; Narosa.
4. M. Majumder, A. Bhattacharyya; Differential Geometry; Books & Allied Pub.
5. I. S. Sokolnikoff; Tensor Analysis; Wiley, New York; 1951.

COURSE OBJECTIVES:

To introduce the fundamental concepts of differential geometry, including curves, surfaces, curvature and geodesics
To develop the ability to analyze geometric structures and apply these concepts in mathematics and various scientific fields

COURSE OUTCOMES:

CO-1 Understanding the Tensor as generalized concept of Vector in E_3 and E_n

CO-2 Understanding Covariant, Contravariant and Mixed Tensors, Algebra of tensors, Contraction, Outer and Inner product, Quotient law in Tensors

CO-3 Familiarize with Metric tensor of Riemannian Space, Christoffel Symbols and covariant differentiation of tensors

CO-4 Acquainted with parametric representations of curves, helix; curvilinear coordinates, intrinsic differentiation, curvature vector and Geodesic

CO-5 Concept of regular surfaces in R^3 and Geodesic curvature of a surface curve

CO-6 Familiarize with Gaussian curvature, Isometry of surfaces, Developable surfaces

Paper: Major–17 (DSC 1) **Code: BMTMMAJ17T**

Title: Advanced Mechanics

Syllabus: **Credit: 6**

Unit -1: Mechanics **[Credit: 5, 75 L]**

Dynamics of Rigid Bodies: **[Credit: 2, 30 L]**

- Moments and Products of inertia (in three-dimensional rectangular co-ordinates), Inertia matrix, Principal values and principal axes of inertia matrix, Principal moments and principal axes of inertia for (i) a rod, (ii) a rectangular plate, (iii) a circular plate, (iv) an elliptic plate, (v) a sphere, (vi) a right circular cone, (vii) a rectangular parallelepiped and (viii) a circular cylinder, Momental Ellipsoid.
- Equation of motion of a rigid body about a fixed axis, Expression for kinetic energy and moment of momentum of a rigid body moving about fixed axis.
- Equations of motion of a rigid body moving in two-dimension, Expression for kinetic energy and angular momentum about the origin of rigid body moving in two dimensions, Necessary and sufficient condition for pure rolling, Two-dimensional motion of a solid of revolution moving on a rough horizontal plane, the following examples of the two-dimensional motion of a rigid body to be studied:
  (i) Motion of a uniform heavy sphere (solid and hollow) along a perfectly rough inclined plane;
  (ii) Motion of a uniform heavy circular cylinder (solid and hollow) along a perfectly rough inclined plane:
  (iii) Motion of a rod when released from a vertical position with one end resting upon a perfectly rough table or smooth table.
  (iv) Motion of a uniform heavy solid sphere along an imperfectly rough inclined plane;
  (v) 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.

Unit-II: Statics **[Credit: 1, 15 L]**

- Forces in three dimensions: Forces, concurrent forces, Parallel forces, Moment of a force, Couple, Resultant of a force and a couple (Fundamental concept only), Reduction of forces in three-dimensions, Pointsot's central axis, conditions of single resultant, conditions of equilibrium.
- Virtual work: Principle of Virtual work, Deduction of the conditions of equilibrium of a particle under coplanar forces from the principle of virtual work, Simple examples of finding tension or thrust in a two-dimensional structure in equilibrium by the principle of virtual work.
- Stable and unstable equilibrium, Coordinates of a body and of a system of bodies, Field of forces, Conservative field, Potential energy of a system, Dirichlet's Energy test of stability, stability of a heavy body resting on a fixed body with smooth surfaces- simple examples.

Unit-III: Elements of Continuum Mechanics & Hydrostatics **[Credit: 2, 30 L]**

- Deformable body, Idea of a continuum (continuous medium), Surface forces or contact forces, Stress at point in a continuous medium, stress vector, components of stress (normal stress and shear stress) in rectangular Cartesian co-ordinate system; stress matrix.
- Definition of ideal fluid and viscous fluid.
- Pressure (pressure at a point in a fluid in equilibrium is same in every direction), Incompressible and compressible fluid, Homogeneous and non-homogeneous fluids.
- Equilibrium of fluids in a given field of force; pressure gradient, Equipressure surfaces.

- Pressure in a heavy homogeneous liquid, Thrust on plane surfaces, Center of pressure, effect of increasing the depth without rotation, Centre of pressure of a triangular & rectangular area and of a circular area immersed in any manner in a heavy homogeneous liquid, Simple problems.
- **Thrust on curved surfaces:** Archemedes' principle, Equilibrium of freely floating bodies under constraints. (Consideration of stability not required).
- **Gas:** Equation of state of a 'perfect gas', Isothermal and adiabatic processes in an isothermal atmosphere, Pressure and temperature in atmosphere in convective equilibrium

Reading References:

1. I. H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th 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. Chorlton, F., Textbook of Dynamics.
4. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies
5. Loney, S. L., Elements of Statics and Dynamics I and II.
6. Ramsey, A. S., Dynamics (Part I).
7. Ghosh, M. C, Analytical Statics.
8. G. C. Gorain, Mathematical Hydrostatics, New Central Book Agency, Kolkata
9. Verma, R. S., A Textbook on Statics, Pothishala, 1962.
10. Matiur Rahman, Md., Statics.
11. Chatterjee, R. N.-Elements of Continuum Mechanics.
12. Love, A. E. H.-Conitnuum Mechanics.

COURSE OBJECTIVES:

To provide an in-depth understanding of advanced topics in mechanics, focusing on rigid body motion, hydrostatics and the application of continuum mechanics in describing the behavior of materials under stress

To analyze complex systems, including the behavior of fluids and solid materials under various conditions using both classical and modern techniques

COURSE OUTCOMES:

CO-1 Understanding the Moments and Product of Inertia and M.I. and P.I. of some Plane Laminas and Rigid Bodies

CO-2 Understanding of Projection Dynamics, the Two-dimensional motion of Rigid Bodies

CO-3 Familiarize with Statics, Reduction of forces in three dimensions and its resultant, concept of couple and Poinsot's central axis

CO-4 Understanding the concept of virtual work and its applications, Stable and unstable equilibrium and idea of equilibrium of heavy inextensible string

CO-5 To develop the concept of equilibrium of fluids in a field of force, pressure and thrust on heavy fluids

CO-6 Familiarize with equation of state of perfect gas, isothermal and adiabatic process in an isothermal atmosphere

Paper: Major–18 (DSC 2) **Code: BMTMMAJ18T**

Title: Operation Research & Calculus of Variations

Syllabus: **Credit: 6**

Unit -1: Operation Research **[Credit: 4, 60 L]**

- Replacement Problems: Introduction, Replacement policies for items whose efficiency deteriorates with time, Individual and group replacement, Replacement policies for items that fail completely.
- Job sequences: Processing of n jobs through two machines, The Algorithm, Processing of n jobs through m machines.
- Project Network: Introduction, Basic differences between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis, Project Crashing, Time cost Trade-off procedure, Updating of the Project.
- Flow Network: Max-flow min-cut theorem, Generalized Max flow min-cut theorem, Linear Programming interpretation of Max-flow min-cut theorem, Minimum cost flows, Min-flow max-cut theorem.
- Inventory control Models: Classification of Inventories, Advantage of Carrying Inventory, Features of Inventory System, Deterministic inventory models including price breaks, Discrete and Continuous probabilistic inventory models, Safety stock and Buffer Stock, Concept of just in time inventory
- Queuing Theory: Introduction, characteristic of Queuing systems, operating characteristics of Queuing system. Probability distribution in Queuing systems. Classification of Queuing models. Poisson and non-Poisson queuing models (M/M/1:∞/FCFS/∞), (M/M/C:∞/FCFS/∞), (M/M/1:N/FCFS/∞), (M/M/C:N/FCFS/∞).

Unit -2: Calculus of Variations **[Credit: 2, 30 L]**

Variation, Linear functional, Deduction of Euler-Lagrange differential equation and some special cases of it, Euler-Lagrange differential equation for multiple dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables. Application of Calculus of variations for the problems of shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem,

Calculus of variations for problems in parametric form, Variational problems with moving boundaries Sturm-Liouville problems, Hamilton's principle, Lagrange's equations, Generalized dynamical entities, vibrating string, vibrating membranes, theory of elasticity – The variational problem of a vibrating elastic plate.

Reading References:

1. J.D. Weist, F.K.Levy: A Management Guide to PERT/ CPM. 2nd Edition, PHI, 1967 (Reprint 2007).
2. Ronald L. Rardin: Optimization in Operations Research, Prentice Hall, 1998.
3. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall, 9th Edition, 2010.
4. Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris: Fundamentals of Queueing Theory, 4th Edition, 2008.
5. Donald Waters: Inventory Control and Management, John Wiley, 2010.
6. R Weinstock, Calculus of Variation, Dover, 1970.
7. M. Gelfand and S. V. Fomin, Calculus of Variations, Dover Publications, 2000
8. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Ninth Edition, 2012
9. S. Gupta, calculus of Variations with Applications, Prentice Hall of India, 1997
10. Gelfand, J.M., Fomin, S.V., Calculus of Variations, Prentice Hall, New Jersey, 1963.

COURSE OBJECTIVES:

Students will learn to apply methods such as linear programming, network flows and queuing theory to solve real world problems in business and engineering. The course on Calculus of variations focuses on the optimization of functional, where students will explore techniques for solving problems involving minimizing and maximizing integrals.

COURSE OUTCOMES:

CO-1 Understanding Non-linear Programming Problem, Quadratic Programming Problem and Integer Programming Problem

CO-2 Understanding the Replacement Problems and Job Sequences

CO-3 Familiarize with Project Network and Flow Network problems

CO-4 To develop the concept of Calculus of Variations for the problems of shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem

CO-5 To develop the concept of Variational problems with moving boundaries, Sturm-Liouville problems, Hamilton's principle, Lagrange's equations, Generalized dynamical entities, vibrating string, vibrating membranes, theory of elasticity - The variational problem of a vibrating elastic plate

MINOR COURSES

(Students have option to choose these courses in Semester-II, Semester-III, Semester-V & Semester-VII)

SEMESTER 2

Paper: Minor-I **Code: BMTMMEB12T**

Title: Algebra and Analytical Geometry in 2D & 3D

Syllabus: **Credit: 4**

Unit-1 Algebra **[Credit: 2, 30 L]**

Complex Numbers, De Moivre's theorem (Statement only) and its applications, Polynomial equations with real coefficient, Multiple roots, Descartes' rule of sign, Relation between roots and coefficients, Transformation of equations, Reciprocal equation, solution of cubic equations-Cardan's method
Inverse of a matrix, Rank of a matrix, Solution of system of m-linear equations with n- variables by matrix methods, Eigen values and Eigen vector of a matrix, Cayley-Hamilton theorem (Statement only) and its use
Group: Definition and examples, Abelian group, Subgroup,

Ring and Field: Definition and examples

Unit-2 Analytical Geometry in 2D & 3D **[Credit: 2, 30 L]**

Analytical Geometry in 2D:

Transformation of Rectangular axes: Translation, Rotation and Rigid body motion, Theory of Invariants, General equation of second degree in two variables, reduction into canonical forms and classification of conics
Pair of straight lines: Condition that the general equation of second degree in two variables may represent two straight lines, Point of intersection, Angle between pair of lines, Angle bisectors
Polar co-ordinate system: polar equation of Straight lines, circles.

Analytical Geometry in 3D:

Plane, Straight line,
Sphere: General Equation, Circle, Sphere through circle

Reference Books

1. J. G. Chakraborty & P. R. Ghosh, Higher Algebra, U N Dhur
2. S. K. Mapa, Higher Algebra, Academic Publisher
3. R. M. Khan, Higher Algebra, Books & Allied
4. J. G. Chakraborty & P. R. Ghosh, Analytical Geometry, U N Dhur
5. R. M. Khan, Introduction to Geometry, Books & Allied
6. S. L. Loney, Coordinate Geometry.

COURSE OBJECTIVES:

To develop a strong foundation in Classical and Abstract Algebra and enhance understanding of Two and Three dimensiona Analytical Geometry.

COURSE OUTCOMES:

CO-1 Understanding of De-Moivre's theorem and its application

CO-2 Learn methods to solve equations, transformed equations, cubic and reciprocal equations

CO-3 Understanding the concept of Row rank, Column rank & Rank of a matrix and Row reduced Echelon form

CO-4 Acquainted with the Existence of solutions of system of Linear Equations and their solution techniques

CO-5 Concept of Eigen values and Eigen vectors of a matrix and Diagonalization of Matrices of order 2 and 3

CO-6 Familiarize with Group, Abelian Group & Subgroup and Ring & Field

CO-7 Understanding of Transformation of Axes and its uses for the reduction of General Equation of Second Degree to Canonical form

CO-8 Understanding geometry of two-dimensional plane figures

CO-9 Familiarize with Polar Co-ordinate system and polar equation of line, circle, conics & tangent and normal to conics

CO-10 Understanding the concept of Three-dimensional space and it's geometry

CO-11 Understanding the geometrical characteristics of Plane, Straight Line and Sphere

SEMESTER 3

Paper: Minor-II **Code: BMTMMEB23T**

Title: Calculus, Differential Equations & Vector Calculus

Syllabus: **Credit: 4**

Unit-I: Calculus **[Credit: 2, 30 L]**

Differential Calculus: Higher order derivatives, Leibnitz rule of successive differentiation and its applications. Taylor's and Maclaurin's Theorems with Lagrange's form of remainder (Statement only), Finite Expansion with Lagrange's form of remainder- sin(x), cos (x), exp(x), log(1+x), Basic ideas of Partial derivative (First & Second order only), Chain Rules, Homogeneous functions, Euler's theorem on homogeneous functions of two variables and its applications.

Integral Calculus: Derivations and illustrations of simple reduction formulae, Rectification & Quadrature of simple plane curves

Unit-II: Differential Equations **[Credit: 1, 15 L]**

Solution of first order and first-degree differential equations: Exact differential equations, condition of exactness, Integrating Factor, Linear Equations.

Differential Equations of first order but not of first degree: Solvable for p, Solvable for x, Solvable for y, Clairaut's form.

Solution of second order linear differential equation with constant coefficients, Particular integrals for polynomial, sine, cosine & exponential functions

Unit-III: Vector Calculus **[Credit: 1, 15 L]**

Differentiability of vector-valued function of one variable, Vector-valued functions of two and three variables, Gradient of scalar function, Divergence and Curl of vector valued functions

Reference Books

1. Santinarayan, Differential Calculus, S Chand
2. Ghosh & Maity, Differential Calculus, New Central Book Agency
3. Das & Mukherjee, Differential Calculus, U N Dhur
4. Ghosh & Maity, Integral Calculus, New Central Book Agency
5. Das & Mukherjee, Integral Calculus & Differential Equations, U N Dhur
6. Ghosh & Maity, Differential Equations, New Central Book Agency
7. Ghosh & Maity, Vector Calculus, New Central Book Agency
8. J.G. Chakraborty & P. R. Ghosh, Vector Analysis, U N Dhur

COURSE OBJECTIVES:

To develop fundamental concepts of Calculus, Ordinary Differential Equations & Vector Calculus

COURSE OUTCOMES:

CO-1 Familiarize with Higher Order Derivatives & Leibnitz Rule for Successive Differentiation with its applications

CO-2 Understanding of Mean Value theorems and its application in finite expansion of functions

CO-3 Understanding the basic ideas Partial Derivatives and applications of Euler's Theorem

CO-4 Familiarize with Reduction Formulae in Integration and applications of Integral Calculus

CO-5 Familiarize with First order linear Ordinary Differential Equations and their solution techniques

CO-6 Identification and solution techniques of First order non-linear Ordinary Differential Equations

CO-7 Familiarize with different solution techniques of Second order linear Ordinary Differential Equations with constant co-efficients

CO-8 Concept of Vector Calculus, Differentiation of vector-valued functions of two or three variables

CO-9 Idea of Gradient, Divergence & Curl of Vectors and their properties

SEMESTER 5

Paper: Minor-III **Code: BMTMMEB35T**

Title: Linear Programming Problem

Syllabus: **Credit: 4**

Linear Programming Problem **[Credit: 4, 60 L]**

- General introduction to optimization problem, Definition of L.P.P., Mathematical formulation of the problem, Canonical & Standard form of L.P.P., Graphical solution of L. P.P.
- Basic solutions, feasible solution, basic feasible & optimal solutions, Reduction of a feasible solution to basic feasible solution.
- Fundamental theorems of L.P.P., Improved basic feasible solutions, Unbounded solution, Condition of optimality, Simplex method, Simplex algorithm, Artificial variable technique (Big M method, Two phase method).
- Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method.
- Transportation Problem (T.P.), Initial basic feasible solutions (different methods like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Loops in T.P. table and their properties, Optimal solutions, Degeneracy in T.P., Unbalanced T.P.
- Assignment Problem, optimal solution by Hungarian Method.

Reference Books

1. Ghosh & Chakraborty, An Introduction to Linear Programming & Game Theory, Maulik Library
2. Karak P. M., Linear Programming with Game Theory, New Central Book Agency
3. Sharma J. K., Operations Research – Theory and Applications
4. Swarup, Gupta & Man Mohan, Operations Research.

COURSE OBJECTIVES:

Familiar with Optimization Problems, Linear Programming Problem and its solution techniques

COURSE OUTCOMES:

CO-1 Introduction of the Optimization Problems and Formation of Linear Programming Problem

CO-2 Familiarize with the basic theorems of LPP and concepts of Basic Solution, Feasible Solution and Basic Feasible Solutions of LPP

CO-3 Understanding the idea of Simplex Algorithm as a Solution technique of LPP and Duality Theory

CO-4 Understanding of Transportation and Assignment Problems with their solution techniques

SEMESTER 7

Paper: Minor-IV **Code: BMTMMEB47T**

Title: Numerical Methods & Basic Computer Programming in C

Syllabus: **Credit: 4**

Unit-I: Numerical Methods **[Credit: 2, 30 L]**

Errors, Absolute & Relative Errors, Round off, Truncation

Solution of Transcendental and Polynomial equations using Bisection method, Fixed Point Iteration, Newton-Raphson method, Geometrical interpretation, convergence conditions, Rate of convergence of these methods.

Solution of System of linear algebraic equations by Gaussian Elimination and Gauss Seidel method and their convergence

Finite difference operators, Lagrange's Interpolation Formula, Newton's Forward and Backward Interpolation Formula.

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule.

Unit-2: Basic Computer Programming in C **[Credit: 2, 30 L]**

Computer Languages: Machine language, Assembly language, computer-high level languages,

Introduction to C programming: Basic structures, Character set, Keywords, Identifiers, Constants, Variable-type declaration

Operators: Arithmetic, Relational, Logical, assignment, Increment, decrement, Conditional. Operator precedence and associativity, Arithmetic expression,

Statement: Input and Output, Define, Assignment, User define, Decision making (branching and looping) – Simple and nested IF, IF – ELSE, LADDER, SWITCH, GOTO, DO, WHILE – DO, FOR, BREAK AND CONTINUE Statements. Arrays- one and two dimensions, user defined functions.

Write simple problems in C programming language, like the following

i. Ascending, descending ordering of numbers.
ii. Finite sum of a series.
iii. Checking of prime numbers.
iv. Factorial of a number.
v. Conversion of temperature from Fahrenheit to Centigrade and vice versa.
vi. Area of a triangle.
vii. To find simple and compound interest.
viii. To find mean, standard deviation.

Reference Books

1. S.A. Mollah; Numerical Analysis and Computational Procedures; Books & Allied.
2. Yashavant Kanetkar; Let Us C; BPB Publications.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
4. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
5. Xavier, C., C Language and Numerical Methods, (New Age Intl (P) Ltd. Pub.)
6. Balaguruswamy, E., Programming in ANSI C (TMH).
7. N. Datta, Computer Programming and Numerical Analysis-An Integrated Approach (Revised edition with C)-(Universities Press)
8. A.K. Jalan, U. Sarkar, Numerical Methods- A Programming-based Approach, Universities Press.

COURSE OBJECTIVES:

To develop numerical mathematical modeling using Interpolation, numerical solution technique to solve algebraic and transcendental equations, numerical quadrature
Familiarize with C language and using C Programming Language numerical solution of basic mathematical properties

COURSE OUTCOMES:

CO-1 Understanding the concept of Convergence, Errors, Rounding-off, Truncation in Numerical Methods

CO-2 Familiarize with Interpolation for equi-spaced and un-equi-spaced arguments

CO-3 Understanding different solution methods for finding root of algebraic and transcendental equations with their geometrical interpretations and convergence conditions

CO-4 Familiarize with solution methods of system of linear equations

CO-5 Concept of Numerical Integration, idea of Newton-Cotes' quadrature formula, Trapezoidal and Simpson's formula

CO-6 Understanding the concept of numerical methods for solving First Order Ordinary Differential Equations using Euler method and Runge-Kutta method of order 2 and 4

CO-7 Understand the basics of computer programming in C, including Boolean algebra and binary number system

CO-8 Able to write C programs using fundamental programming structures such as variables, operators, conditional statements (IF, IF-ELSE, LADDER, SWITCH), loops (DO, WHILE-DO, FOR), and arrays (one and two dimensions)

SKILL ENHANCEMENT COURSE

(Students have option to choose this course in any of Semester-I / Semester-II / Semester-III)

Paper: SEC 1/ 2/ 3 **Code: BMTMSEC01/02/ 03T**

Title: Discrete Mathematics & Graph Theory

Syllabus: **Credit: 3**

Unit-I: Discrete Mathematics **[Credit: 2, 30 L]**

- **Set Theory:** sets and classes, relations and functions, recursive definitions, posets, Zorn's lemma, cardinal and ordinal numbers.
- **Logic:** propositional and predicate calculus, well-formed formulas, tautologies, equivalence, normal forms, theory of inference.
- **Combinatorics:** permutation and combinations, partitions, pigeonhole principle, inclusion-exclusion principle, generating functions, recurrence relations.

Unit-II: Graph Theory **[Credit: 1, 15 L]**

Graph Theory: graphs and digraphs, Eulerian cycle and Hamiltonian cycle, adjacency and incidence matrices, vertex colouring, planarity, trees.

Reading References

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.
4. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
6. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
7. S. Santha, Discrete Mathematics (Cengage Learning).
8. S Pirzada, An Introduction to Graph Theory, Universities Press.

COURSE OBJECTIVES:

To develop the application of Discrete Mathematics and Graph Theory in real life problems

COURSE OUTCOMES:

CO-1 Elementary idea of sets and Relations with their applications

CO-2 Precedence of logical operators and propositional equivalency

CO-3 Concept of predicates and quantifiers

CO-4 Concept and basic properties of Graphs

CO-5 Understanding of Eulerian and Hamiltonian Graphs

CO-6 Representation of Graph by matrix (Adjacency and Incidence matrix)

MULTIDISCIPLINARY COURSE

(Students have option to choose this course in Semester-III)

Paper: MDC **Code: BMTMMDC03T**

Title: Vedic Mathematics

Syllabus: **Credit: 3**

Vedic Mathematics **[Credit: 3, 45 L]**

- Addition, Subtraction, Multiplication, Division, Divisibility, Flag Method, Test of Divisibility, Mixed Operations.
- Square & Square root, Cube & Cube root, Decimal, Factorization, Highest Common Factor (HCF)
- Simple Equations, Quadratic Equations, Cubic Equations, Biquadratic Equations, Simultaneous Equations.
- Factorizations and Differential Calculus, Partial Fractions, Integration by Partial Fractions, Pythagoras Theorem, Appolonius Theorem, Analytical Geometry.
- Indian Mathematicians (Katyayana, Pingala, Aryabhatta, Varahmihira, Brahmagupta, Bhaskara I, Sridhara, Mahavira, Bhaskara II, Madhava, Radhakanta Sikdar, Srinivasa Ramanujan, P.C. Mahalanobis, C. R. Rao, Aushutosh Mukherjee, Shakuntala Devi).

Reading References

1. Fundamentals & Applications of Vedic Mathematics: SCERT, Delhi; 2014.
2. Shashtri, P.R. Vedic Mathematics. Meerut: Arihant Publications, 7th Ed. 2011.
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COURSE OBJECTIVES:

To introduce ancient Indian techniques for solving mathematical problems quickly and efficiently. Students will learn methods such as mental calculation, simplification strategies and shortcuts for arithmetic, algebra and geometry to enhance problem solving skills.

COURSE OUTCOMES:

CO-1 Develop the ability to perform complex arithmetic calculations rapidly using Vedic mathematics techniques

CO-2 Gain proficiency in applying Vedic methods to simplify algebraic expressions and solve equations efficiently.

CO-3 Learn to use Vedic Strategies for solving problems in geometry with minimal effort.

CO-4 Learn about ancient Indian Mathematicians and their contributions in various branches in mathematics.