VIDYASAGAR UNIVERSITY

MATHEMATICS

(Honours & General)

Under Graduate Syllabus

(3 Tier Examination Pattern)

w.e.f. 2014-2015

REVISED

Vidyasagar University

Midnapore 721 102

West Bengal

MATHEMATICS
(HONOURS)

PART-I

Paper - I:

Group A (Marks 30) : Classical Algebra
Group B (Marks 35) : Abstract Algebra
Group C (Marks 25) : Linear Algebra – I
Internal Assessment (Marks 10)

Paper - II:

Group A (Marks 35): Real Analysis - I
Group B (Marks 20): Several Variables and Applications
Group C (Marks 20): Analytical Geometry of Two Dimensions
Group D (Marks 15): Differential Equations - I
Internal Assessment (Marks 10)

PART-II

Paper - III:

Group A (Marks 25) : Vector Analysis
Group B (Marks 30) : Analytical Geometry of Three Dimensions
Group C (Marks 35) : Linear Programming and Game Theory
Internal Assessment (Marks 10)

Paper - IV:

Group A (Marks 40) : Analytical Dynamics of Particles
Group B (Marks 30) : Analytical Statics
Group C (Marks 20) : Differential Equations – II
Internal Assessment (Marks 10)

Paper - V:

Group A (Marks 50): Real Analysis - II
Group B (Marks 15): Metric Space
Group C (Marks 10): Complex Analysis
Group D (Marks 15): Tensor Calculus
Internal Assessment (Marks 10)

PART-III

Paper - VI:

Group A (Marks 30) : Rigid Dynamics
Group B (Marks 25) : Hydrostatics
Group C (Marks 20) : Discrete Mathematics
Group D (Marks 15) : Mathematical Modeling
Internal Assessment (Marks 10)

Paper - VII:

Group A (Marks 30) : Elements of Computer Science
Group B (Marks 35) : Mathematical Theory of Probability
Group C (Marks 25) : Mathematical Statistics
Internal Assessment (Marks 10)

Paper – VIII:

Group A (Marks 25) : Numerical Analysis
Group B (Marks 25) : Real Analysis-III
Group C (Marks 10) : Linear Algebra-II
Group D (Marks 30): Computer Practical
Internal Assessment (Marks 10)

PART I

Paper-I

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group – A

Classical Algebra **Marks: 30**

1. Complex numbers: De-Moivre's theorem and its applications, Exponential, Sine, Cosine and Logarithm of complex number, definition of a^z (a $\neq$ 0). Inverse circular and hyperbolic functions.

2. Polynomials with real co-efficient: Fundamental theorem of classical algebra (no proof required), n-th degree polynomial equations has exactly n roots. Nature of roots of an equation (surd / complex roots occur in pair).

   Statement of Descartes' rule of signs and Sturm's theorem and their applications, Location of Roots, Multiple roots, Relations between roots and coefficients, symmetric functions of the roots, transformations of equations, Reciprocal equation, Cardan's method of solution of a cubic equation, Ferrari's method of solution of a biquadratic equation, Binomial equations, special roots.

3. Inequality: A.M. $\geq$ G.M. $\geq$ H.M. and its generalisations like the theorem of weighted means and m-th power theorem, Cauchy's inequality and their direct applications.

Group - B

Abstract Algebra **Marks: 35**

1. Sets and Mappings: Revision of basic set theory, Cartesian product of sets, binary relation, equivalence relation and partition. Mappings: Injective, surjective, bijective, identity and inverse mappings, composition of mappings and its associativity, binary operations.

2. Integers: Natural numbers (Peano's axioms), statement of well ordering principle, first principle of mathematical induction, Second principle of mathematical Induction, division algorithm, G.C.D. of two integers, existence and uniqueness of G.C.D.

   Prime integers: Theorems of prime numbers including Euclids, unique factorizations theorem. Congruences: Properties and algebra of congruences, power of congruence, Fermat's theorem, Wilson's theorem, Euler's phi function, Fermat's theorem.

3. Introduction to group theory: Groupoid, semi group, quasi group, monoid, group, abelian group, examples of finite/infinite-groups taken from various branches.

   Properties deducible from the definition of group including solvability of equations like $ax = b$, $ya = b$. A finite semigroup in which both the cancellation laws hold is a group.

   Integral powers of an element and laws of indices in a group, order of an element of a group.

   Sub-groups: Necessary and sufficient condition for a subset of a group to be subgroup. Intersection and union of two subgroups, cosets and Lagrange's theorem. Permutations, symmetric group, alternating group. Cyclic groups, subgroups of cyclic group, normal subgroups, concepts of homomorphism and Isomorphism of group.

4. Introduction to rings and fields: Definition and examples of ring, properties of rings directly follows from the definition, unitary and commutative rings, divisors of zero, integral domain.

   Field: Definition and examples of field, every field is an integral domain, every finite integral domain is a field, characteristic of a Ring and of an integral domain, definitions of sub-ring and sub-field, statement of necessary and sufficient condition for a subset of a ring(field) to be a subring (subfield).

Reference Books

1. Bernard and Child: *Higher Algebra*.
2. Burnside and Panton: *Theory of Equations (Vol. I)*.
3. D. S. Malik, J.M. Mordeson and M.K. Sen: *Fundamentals of Abstract Algebra*.
4. Sharma, Shankar, Shah: *Abstract I: A Basic course in Abstract Algebra*.
5. Shanti Narayan: *A Text Book of Matrices*.
6. J. B. Fraleigh: *A First Course in Abstract Algebra*.
7. I. N. Herstein: *Topics in Algebra*.
8. Surjeet Singh and Q. Zameeruddin: *Modern Algebra*.
9. S. K. Mapa: *Higher Algebra (Abstract and Linear)*.
10. M. K. Sen, P. Mukhopadhyay and S. Ghosh: *Topics in Abstract Algebra*.
11. Hadley: *Linear Algebra*.

Group - C

Linear Algebra – I **Marks: 25**

1. Matrices (n x n) of real numbers, Algebra of matrices, symmetric and skew-symmetric matrices, orthogonal matrix, trace of a matrix.

2. Determinant of a square matrix of order n: Basic properties, minors and co-factors, Laplace's expansion of a determinant, Product of two determinants, adjugate and reciprocal determinants, symmetric and skew-symmetric determinants up to fourth order, Jacobi's theorem.

3. Adjoint of a square matrix, for a square matrix $A. (adjA) = (adjA).A = (detA).I_n$, invertible matrix, non-singularity, inverse of an orthogonal matrix. Elementary operations on matrices, echelon matrix, rank of a matrix, determination of rank of a matrix (statement and relevant results only), elementary matrices, normal form.

4. Congruences of matrices: Statement and application of relevant results, normal form of a matrix under Congruence.

5. Vector or linear space over a field with special reference to spaces of n-tuples of real numbers. Examples of vector space from different branches of mathematics,

subspace, union and intersection of subspaces, linear combinations, linear dependence and independence of set of vectors, linear span, generator of a vector space, basis, dimension of a real vector space, deletion theorem, extension theorem, replacement theorem, extraction of a basis from given generators, formation of a basis from a linearly independent subset.

6. Linear system of equations: Linear homogeneous system of equations, solution space, related results using idea of rank, necessary and sufficient condition for consistency of a linear non-homogeneous system of equations.

7. Inner product space: Definition and examples, norm, Euclidean vector space, orthogonality of vectors, orthonormal basis, Gram-Schmidt process of orthogonalisation.

8. Characteristic polynomial and equation of a matrix, Cayley-Hamilton theorem, Eigen values and Eigen vectors of a square matrix, diagonalisation of matrices, real quadratic form and reduction to canonical forms and classification.

Reference Books

1. Bernard and Child: *Higher Algebra*.
2. D.S. Malik, J.M. Mordeson and M.K Sen: *Fundamentals of Abstract Algebra*.
3. K.B. Datta: *Matrix and Linear Algebra*.
4. Shanti Narayan: *A Text Book of Matrices*.
5. J.B. Fraleigh: *A First Course in Abstract Algebra*.
6. I. N. Herstein: *Topics in Algebra*.
7. Surjeet Singh and Q. Zameeruddin: *Modern Algebra*.
8. S.K. Mapa: *Higher Algebra (Classical)*.
9. S.K. Mapa: *Higher Algebra (Abstract and Linear)*.
10. M.K. Sen, P. Mukhopadhyay and S. Ghosh: *Topics in Abstract Algebra.*
11. Hadley: *Linear Algebra*.

Paper-II

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Real Analysis – I **Marks: 35**

1. Intuitive ideas of natural numbers, integers, rational numbers and Irrational numbers, field axioms, order axioms, bounded set, lub of a set and the Completeness axiom (or least upper bound (lub) axiom) for the introduction of real number system, Consequences of lub axiom, Archimedian property of real numbers, rational number is Archimedian ordered field but not order complete, density property of rational and real numbers, arithmetic and geometric continuum of real numbers, extended real number system.

2. Open sets in terms of interior points, limit points, closed sets, ideas- of derived sets, boundary point, closure of a set, basic properties of open and closed sets (union, intersection and complement), Bolzano Weierstrass theorem, idea of open cover of a set, Heine-Borel theorem, denumerable and non-denumerable sets, denumerability of rational numbers, nondenumerability of the set of all irrational numbers and an interval.

3. Sequences. Bounds and limits, convergence and divergence, operations on limits, monotonic sequences and their convergence. Definition of *e*. Nested interval theorem, every bounded sequence has a convergent subsequence, accumulation point of a set as limit of a sequence, upper and lower limits (lub and glb of a set containing all subsequential limits). Inequalities with upper and lower limits. Cauchy sequence, Cauchy's general principle of convergence, first and second limit theorem of Cauchy, knowledge of important sequences and their convergence.

4. Infinite series of constant terms: Convergence, divergence, Cauchy's principle of convergence, Series of non-negative terms: Condition of convergence -Tests of convergence: condensation test, upper and lower limit, criteria of convergence. (i) comparison test, (ii) Root test, (iii) Kumer's test, (iv)Ratio test, (v) Raabe's test, (vi) Gauss's test.

Series of arbitrary terms, absolute convergence, alternating series, Leibnitz theorem for alternating series, absolutely and conditionally convergent series, idea of rearrangements of the terms of a series, examples of series that changes the sum after a suitable rearrangement, Riemann's rearrangement theorem (statement only).

5. Real-valued functions defined on subsets' of the real line: in particular, real valued functions defined on an interval, limit at a point of a function defined on an interval, Algebra of limits, Infinite limits, Cauchy's Criteria on limit (no proof), bounded functions, monotone functions.

   Continuity at a point, on an interval of a function (continuity of functions x^n, a^x, log x, sin x, cos x, etc. to be assumed), properties of continuous function on a closed interval, existence of inverse functions of strictly monotone functions and its continuity. uniform continuity on an interval (only definition) and examples.

   Discontinuities of different kinds, discontinuities of monotone functions, denumerability of such points' of discontinuity.

6. Derivative, its physical and geometrical significance, sign of derivative, theorem on derivatives, condition of differentiability, rules of differentiation, chain rule and differentiation of inverse function, derivatives of higher order, Leibnitz theorem, Rolle's theorem, Lagrange's M.V.T., Cauchy's M.V.T., Darboux theorem, Taylor's theorem with different forms of remainder, Taylor's and Maclaurin's theorem in finite form with different forms remainder. Taylor's and Maclaurin's theorem-infinite forms. Expansion of e^x, a^x $(a > 0)$, $log(1 + x)$, $(1 + x)^m$, $sin\ x$, $cos\ x$ etc. with their respective ranges of validity.

7. Indeterminate form, L' Hospital's rule and its consequences.

8. Reduction formulae for $x^n e^x$, $sin^n x$, $cos^n x$, $sin^m x$, $cos^n x$, $tan^n x$, $cotnx$, $sec^n x$, $cosec^n x$, $1/(a+bcosx)^n$, $1/(x^2 + a^2)^n$, $x^m/(a + bx^n)$, $(lcosx + msinx)/(pcosx + qsinx)$ etc.

Reference Books

1. T.M. Apostol: *Calculus-I.*
2. W. Rudin: *Principles of Mathematical Analysis*.
3. Courant and John: *Differential and Integral Calculus (Vol. I and Vol. II).*
4. Philips: *A Course of Analysis*.
5. R. G. Bertle and D. R. Sherbert: *Introduction to Real Analysis*.
6. Goldberg: *Methods of Real Analysis*
7. Shanti Narayan: *Mathematical Analysis*.
8. Shanti Narayan: *Differential Calculus*.
9. Shanti Narayan: *Integral Calculus*.
10. Malik and Arora: *Mathematical Analysis*
11. K. Knopp: *Theory and Applications of Infinite Series*.
12. Maity and Ghosh: *Integral Calculus.*
13. Mapa: *An Introduction of Real Analysis*
14. Maity and Ghosh: Differential Calculus, *An Introduction to Analysis*.

Group – B

Several Variables and Applications **Marks: 20**

1. Function of several variables, limit, continuity, double limit and repeated limit, partial differentiation, chain rule, exact differentiation of implicit functions, successive partial derivatives, Schwarz's theorem and Young's theorem, Euler's theorem of homogeneous function and its converse (up to three variables), Jacobian with simple properties.

2. Tangent, normal, curvature, asymptotes, envelope, singular points, curve tracing.

Reference Books

1. Maity and Ghosh: *Differential Calculus, An Introduction to Analysis*.
2. Shanti Narayan: *Differential Calculus*.

Group – C

Analytical Geometry of Two Dimensions **Marks: 20**

1. Transformation of rectangular axis - Translations, rotation and their combination, general equation of second degree in two variables and its reduction to canonical equations, classifications of conics.

2. Pairs of straight lines, condition that the general equation of second degree in two variables may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Angle bisector, equation of two lines joining the origin to the points in which a line meets a conic.

3. Circle, Parabola, Ellipse and Hyperbola, Tangent and normals, Equations of pair-of tangents from an external point, chord of contact, pole and polar, conjugate points, conjugate lines, conjugate diameters.

4. Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole, equation of tangent, normal, chord of contact.

Reference Books

1. M.C. Chaki: *A Text Book of Analytic Geometry*.
2. S.L. Loney: *Co-ordinate Geometry*.
3. C. Smith: *Elementary Treatise on Conic Sections*.
4. Ghosh and Chakraborty: *Analytical Geometry*.
5. N. Dutta and R.N. Jana: *Analytical Geometry*.
6. Vittal: *Analytical Geometry of 2D and 3D.*

Group - D

Differential Equations –I **Marks: 15**

1. First order differential equation of first degree and of higher degree: Separable, homogeneous and exact equations, condition of exactness, working knowledge of the rules of finding integrating factors, equation reducible to first order linear equations, Clairaut's equation, singular solution.

2. Application of differential equation to geometrical and physical problems, orthogonal trajectory.

3. Higher order linear differential equations with constant coefficient: complementary function, particular integral, method of undetermined coefficients, symbolic operator D.

4. Second order linear equations with variable coefficients, exact equations, Euler's homogeneous equation, reduction to an equation of constant coefficient. Transformation of equation by changing the dependent variable / the independent variable. Method of variation of parameter. Reduction of second order linear differential equation when one solution is known.

5. Simple Eigen-value problems.

Reference Books

1. I. Murray: *Differential Equations*.
2. Piaggio: *Differential Equations*.
3. Chakraborty and Ghosh: *Differential Equations*.
4. Maity and Ghosh: *Differential Equations*.
5. S. L. Ross: *Differential Equations*.
6. Rukmangdachari: *Differential Equations*.

PART II

Paper-III

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Vector Analysis **Marks: 25**

1. Scalar triple products and vector triple products, product of four vectors, reciprocal sets of vectors. Application in mechanics, geometry and trigonometry.

   Vector equations of straight lines and planes. Volume of a tetrahedron, shortest distance between two skew lines.

2. Ordinary derivative of vector. Space curves, parametric equations. Continuity and differentiability. Partial derivatives of vectors. Differential of vectors. Elements of differential geometry. Frenet Srenet's formula. Application of vector calculus in mechanics particularly to planetary motions.

3. Gradient, divergence and rot (or curl) of a vector. The vector differential operator ∇, gradient, divergence, rot (or curl). Geometrical and physical interpretations. Formulae involving ∇. Invariance.

4. Vector integral calculus: Ordinary integrals of vectors. Line integrals. Surface integrals. Volume integrals. Green's theorem. Statement and verification of the divergence theorem of Gauss and Stoke's theorem. Related integral theorems, applications.

Reference Books

1. M. R. Speizel: *Vector Analysis and Tensor Calculus*.
2. Maity and Ghosh: Vector Analysis.
3. M.C.Chaki: *Vector Analysis*.
4. B.Spain: *Vector Analysis*.
5. C.E.Weatherburn: *Elementary Vector Analysis*

Group – B

Analytical Geometry of Three Dimensions **Marks: 30**

1. Rectangular cartesian co-ordinates in space, Concept of a geometric vector (directed lines segment). Projection of a vector on a co-ordinate axis, inclination of a vector with an axis, co-ordinates of a vector, direction cosines of a vector, distance between two points. Division of a directed line segment in a given ratio, the equation of a surface and the equation of a curve.

2. Equation of plane: General, intercept and normal form. The sides of a plane, signed distance of a point from a plane. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes, bi-sectors of angle between two intersecting planes, Parallelism and perpendicularity of two planes.

3. Straight line in space: its equation in symmetrical (canonical) and parametric forms. Direction ratio and direction cosines, canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Condition for Parallelism and perpendicularity of two straight lines, of a straight line and a plane, Equations of skew lines, Distance of a point from a straight line. Shortest distance between two skew lines.

4. Sphere, Cone, Cylinder. Surface of revolution, Ruled surface: study of their shapeS and canonical equations.

5. Enveloping cone and enveloping cylinder.
   Tangents, tangent planes, normals and generating lines of quadrics.

6. Transformation of rectangular axes: translation, rotation and their combinations. General equation of second degree in three variables: reduction to canonical (normal) forms. Classification of quadrics and their equation in canonical forms.

Reference Books

1. M.C. Chaki: *A Text Book of Analytic Geometry*.
2. S.L. Loney: *Co-ordinate Geometry*.

3. J.T. Bell: Co-ordinate: *Geometry of Three Dimensions*.
4. C. Smith: *Solid Analytical Geometry*.
5. Ghosh and Chakraborty: *Analytical Geometry*.
6. N. Dutta and R.N. Jana: *Analytical Geometry*.
7. Vittal: *Analytical Geometry of 2D and 3D.*

Group – C

Linear Programming and Game Theory **Marks: 35**

1. Inequations, formation of problems from daily life involving inequations, slack and surplus variables, definition of L.P.P., canonical, standard and matrix form of L.P.P., solution of L.P.P by graphical method. Basic solutions, feasible solution and basic feasible solutions, degenerate and non-degenerate B.F.S., vectors, bases and dimension, convex sets, convex hull, convex cone, convex polyhedral and simplex, hyperplane, polytope, polyhedral, separating and supporting hyperplane. The collection of all feasible solution of a L.P.P. constitutes a convex set whose extreme point correspond to its B.F.S. The objective function has its optimum value at an extreme point of the convex polyhedron generated by the set of feasible solutions, a B.F.S. to a L.P.P. corresponds to an extreme point of the convex set of feasible solutions, if the objective function assumes its optimal value at more than one extreme points, then every convex combination of these extreme points also gives the optimal value of the objective function. If the L.P.P. admits an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to B.F.S.

2. Theory of simplex method, feasibility and optimality conditions, The algorithm, Unbounded solution, alternative optimal. Two phase method, Charne's Big-M method, degeneracy in L.P.P. and its resolution. Cycling (definition only). Duality, The dual of the dual is primal, weak and strong duality theorems, solution of the dual (primal) from the simplex table of the primal (dual).

3. Transportation and assignment problems: Formulation of balanced and unbalanced problems and their optimal solutions travelling salesman problems and their optimal solutions.

4. Game theory: Concept of game problems, rectangular game. Pure strategy and mixed strategy, saddle point, optimal strategy and value of the game, dominance, fundamental theorem of rectangular games, various methods (algebric method, graphical method, dominance principle and Simplex method) of solving rectangular games.

Reference Books

1. G. Hadley: *Linear Programming*.
2. J. G. Chakraborty and P. R. Ghosh: *Linear Programming and Game Theory*.
3. P. M. Karak: *Linear Programming*.
4. H. A. Taha: *Operations Research*.
5. S. D. Sharma: *Operations Research*.
6. Kanti Swamp, Gupta and Manmohon: *Operations Research*.
7. S. I. Gass: Linear Programming: *Methods and Application*.

Paper-IV

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Analytical Dynamics of Particles **Marks: 40**

1. Basic Concepts: Particle and rigid body; frame of reference, rest and motion, position vector, velocity and acceleration, mass, force and Newton's laws of motion.

2. Motion of a particle in one dimension: Rectilinear motion under constant and variable forces, impulse and impulsive forces, linear momentum, kinetic energy, work, power, conservative forces depending on position, potential energy and principle of conservation of linear momentum and energy, collision of elastic bodies, falling bodies including various problems, motion under gravity with resistance varying as integral powers of velocity. S.H.M. linearly damped oscillation, forced oscillations, damped forced oscillations, principle of superposition, strings and springs, varying mass problem, rockets and falling rain.

3. Motion of a particle in a plane: Expressions for velocity and acceleration in cartesian and polar coordinates, expressions for tangential and normal acceleration, equation of motion in cartesian (w.r.to fixed and rotation frames) and polar coordinates, momentum (linear and angular), work, energy, conservative forces, principle of conservation of linear momentum, angular momentum and energy. Central forces and central orbits, motion under inverse square law (attractive and repulsive). Escape velocity. Planetary motion and Kepler's laws, motion of an artificial satellite, geo-stationary orbits, stability of nearly circular motion, disturbed elliptic orbit, constrained motion, simple and cycloidal pendulum, motion on rough curves (circle, parabola, ellipse, cycloid etc.) under gravity. Motion in resisting medium. Projectiles in a resisting medium when resistance varies as an integral power of velocity.

Reference Books

1. S.L. Loney: *An Elementary Treatise on the Dynamics of a particle and of rigid bodies.*
2. A. S. Ramsey: *Dynamics, Vol-I.*
3. F. Chorlton: *Dynamics.*
4. J. G. Chakraborty and P. R. Ghosh: *Advanced Analytical Dynamics*.
5. N. Datta and R. N. Jana: *Dynamics of a Particle*.
6. S. Ganguly and S. Saha: *Analytical dynamics of a particle*.

Group - B

Analytical Statics **Marks: 30**

1. Friction: Laws of Friction, Angle of friction, Cone of friction. To find the positions of equilibrium of a particle lying on a (i) rough plane curve, (ii) rough surface under the action of any given forces.

2. Centre of Gravity: General formula for the determination of C.G. Determination of position of C.G. of any arc, area of solid of known shape by method of integration.

3. Astatic Equilibrium, Astatic Centre. Positions of equilibrium of a particle lying on a smooth plane curve under action of given forces. Action at a joint in a frame work.

4. Virtual work: Principle of virtual work for a single particle. Deduction of the conditions of equilibrium of a particle under coplanar forces from the principle of virtual work. The principle of virtual work for a rigid body. Forces which do not appear in the equation of virtual work. Forces which appear in the equation of virtual work. The principle of virtual work for any system of coplanar forces acting on a rigid body. Converse of the principle of virtual work.

5. Stable and Unstable equilibrium. Co-ordinates of a body and of a system of bodies. Field of forces. Conservative field. Potential energy of a system. The energy test of stability. Condition of stability of equilibrium of a perfectly rough heavy body lying on fixed body. Rocking stones.

6. Forces in three dimensions. Moment of a force about a line. Axis of a couple. Resultant of any two couples acting on a body. Resultant of any number of couples acting on a rigid body. Reduction of a system of forces acting on a rigid body. Resultant force in an invariant of the system but the resultant couple is not an invariant.

   Conditions of equilibrium of a system of forces acting on a body. Deductions of the conditions of equilibrium of a system of forces acting on a rigid body from the principle of virtual work. Poinsot's central axis. A given system of forces can have only one central axis. Wrench, Pitch, Intensity and Screw. Condition that a given system of forces may have a single resultant. Invariants of a given system of forces. Equation of the central axis of a given system of forces.

Reference Books

1. S. L. Loney: *An Elementary Treatise on Statics*.
2. A. S. Ramsey: *Statics*.
3. M. C. Ghosh: *Analytical Statics*.
4. S. Mondal: *Analytical Statics.*

Group -C

Differential Equations-II **Marks: 20**

1. Simultaneous differential equation with constant coefficients up to second order.

2. Power series solution of ordinary differential equation at an ordinary point.

3. Partial differential equation: Introduction, formulation of P.D.E. Solution of first order linear P.D.E.: Lagrange's method.

4. Definition of Laplace transform, Elementary properties of Laplace transform, Laplace transform of derivatives, Laplace transform of integrals, Formulae of inverse Laplace transform, Statement of Convolution theorem, solution of G.D.E. up to second order wi.th constant coefficient using Laplace transform.

Reference Books

1. Murray: *Differential Equations*.
2. Piaggio: *Differential Equations*.
3. Chakraborty and Ghosh: *Differential Equations*.
4. Maity and Ghosh: *Differential Equations*.
5. S. L. Ross: *Differential Equations*.
6. 1. N. Sneddon: *Partial Differential Equations*.
7. Rukmangdachari: *Differential Equations*.

Paper - V

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Real Analysis – II **Marks: 50**

1. Riemann theory of integration: Partition and refinement of partition of a closed and bounded interval, Upper Darboux sum and Lower Darboux sum and associated results, upper integral and lower integral, Darbbux theorem, Darboux definition of integration over a closed and bounded interval, Riemann's definition of integrability, equivalence of Darboux definition of integrability (statement only), necessary and sufficient conditions of Riemann integrability, Integrability of continuous, monotonic and piecewise continuous functions with finite number of points of discontinuities, infinite number of points of discontinuities having finite number of limit points, integrability of sum, scalar multiple, product, quotient, modulus of integrable functions. Functions defined by integrals, their continuity and differentiability, Fundamental theorem of integral calculus. First mean value theorem and second mean value theorem (Bonnet and Weierstrass's form (no proof of integral calculus. Definition of log x as an integral and deduction of simple properties.
2. Improper integral: Necessary and sufficient condition for convergence of improper integral(for unbounded function and unbounded range of integration), comparison and limit test for convergence, absolute and non-absolute convergence, Abel's and Dirichlet's test for convergence of the integral of a product(statement only), Beta and Gamma functions, their convergence, relation and simple properties.
3. Differentiation and integration w.r.to parameter under integral sign, statement of relevant theorem.
4. Multiple integral: Concept of upper sum, lower sum, upper integral, lower integral and Double integral (no rigorous statement is needed), statement of existence theorem for continuous function, change of order of integration, Triple integral, change of variables in double and triple integral (problem only), determination of volume and surface area by multiple integral (problem only).
5. Concept of implicit function: statement and simple application of implicit function theorem for two variables, differentiation of implicit function.

6. Mean value and Taylor's theorem for function of two variables, Transformation of variables. Maxima and minima of functions of two or more variables. Lagrange's method of undetermined multipliers (up to four variables), concept of saddle point.

Reference Books

1. T. M. Apostol: *Calculus-I.*
2. W. Rudin: *Principles of Mathematical Analysis*.
3. Courant and John: *Differential and Integral Calculus (Vol. I and Vol. II).*
4. Philips: *A Course of Analysis*.
5. R. G. BertIe and D. R. Sherbert: *Introduction to Real Analysis*.
6. Goldberg: *Methods of Real Analysis*.
7. Shanti Narayan: *Mathematical Analysis*.
8. Shanti Narayan: *Differential Calculus*.
9. Shanti Narayan: *Integral Calculus*.
10. Malik and Arora: *Mathematical Analysis.*
11. K. Knopp: *Theory and Applications of Infinite Series*.
12. Maity and Ghosh: *Integral Calculus*.
13. Mapa: *An Introduction of Real Analysis*
14. Maity and Ghosh: Diffential Calculus, *An Introduction to Analysis*.

Group - B

Metric Space **Marks: 15**

1. Definition and examples of metric spaces such as R^n $(n \geq 1)$, l_∞, l_p, C[a,b]. Open and closed ball, Neighborhoods of a point, open set, closed set (defined as a complement of an open set).
   Union and intersection of open and closed sets, limit point of a set, interior point and interior of a set, boundary points and boundary of a set, elementary properties of interior, closure and boundary of a set, bounded set, distance between a point and a set, distance between two sets.
2. Sub-space of a metric space, sequence, convergence sequence, Cauchy sequences. Complete and incomplete metric spaces completeness of R^n $(n \geq 1)$, C[a,b]. Cantor's intersection theorem.

Reference Books

1. E. T. Copson: *Metric spaces*.
2. Malik and Arora: *Mathematical Analysis*.
3. B. K. Lahiri: *Elements of Functional Analysis*.
4. P. K. Jain and K. Ahmed: *Metric Spaces*.

Group - C

Complex Analysis **Marks: 10**

1. Complex numbers as ordered pairs. Geometrical representation of complex numbers. Extended Complex plane. Stereographic projection.
2. Complex functions: Limit, Continuity and differentiability of complex functions. Cauchy - Riemann Equations in Cartesian and Polar forms, Analytic functions. Sufficient conditions of Differentiability (Statement only), Harmonic function. Conjugate harmonic function, statement of Milne's Method.

Reference Books

1. E.T. Copson: *Complex Analysis*.
2. Speizel: *Complex Analysis*.
3. R. V. Churchill and J.W. Brow: *Complex Variables and Applications*.
4. ITL ESL: *Complex Analysis*.

Group - D

Tensor Calculus **Marks: 15**

1. Spaces of n dimension, Transformation of co-ordinates, Contravariant and covariant vectors. Scalar invariants, contravariant, covariant and mixed tensor. The Kroneckar delta. Symmetric and Skew-symmetric tensor.
2. Addition, subtraction, outer product, contraction, inner multiplication, Quotient law.

3. The line element and the metric tensor; Riemannian space, conjugate or reciprocal tensor.
4. Christoffel symbols and their laws transformation, covariant differentiation of vectors and tensors, covariant differentiations of sum and products. Divergence of a vector, Laplacian of a scalar invariant.
5. Curvature tensors and Ricci tensor, covariant curvature tensor.

Reference Books

1. H. Lass: *Vector and Tensor Analysis*.
2. M. C. Chaki: *A text book of Tensor Analysis*.
3. F. Goreux: *Differential Geometry*.
4. Barry Spain: *Tensor Calculus*.

PART III

Paper - VI

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Rigid Dynamics **Marks: 30**

1. Moment and product of inertia, Momental ellipsoid, Equimomental system, Principal axis, D'Alembert's principle. D'Alembert's equations of motion. Principles of moments, Principles of conservations of linear and angular momentum. Independence of the motion of centre of inertia and the motion relative to the centre of inertia. Principle of energy. Principle of conservation of energy.

2. 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 a fixed axis. Compound pendulum. Interchangeability of the points of a suspension and centre of oscillation. Minimum time of oscillation. Reaction of axis of rotation.

3. Equations of motion of a rigid body moving in two dimensions. Expression for kinetic energy and angular momentum about the origin of a rigid body moving in two dimensions. Two dimensional motion of a solid of revolution down a rough inclined plane. Necessary and sufficient condition for pure rolling. Two dimensional motion of a solid of revolution moving on a rough horizontal plane.

4. Equations of motion under impulsive forces. Equation of motion about a fixed axis under impulsive forces. Centre of percussion. To show that (i) if there is a definite straight line such that the sum of the moments of the external impulses acting on a system of particles about it vanishes, then the total angular momentum of the system about that line remains unaltered, (ii) the change of K.E. of a system of particles moving in any manner under the application of impulsive forces is equal to the work done by the impulsive forces. Impulsive forces applied to a rigid body moving in two dimensions.

Reference Books

1. S. L. Loney: *An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies.*
2. Chakraborty and Ghosh: *Advanced Algebra Dynamics*.
3. Mollah: *Rigid Dynamics.*

Group - B

Hydrostatics **Marks: 25**

1. Definition of Fluid, Perfect Fluid, Pressure. To prove that the pressure at a point in a fluid in equilibrium is the same in every direction. Transmissibility of liquid pressure. Pressure of heavy fluids. To prove –

   (a) In a fluid at rest under gravity the pressure is the same at all points in the same horizontal plane.

   (b) In a homogeneous fluid at rest under gravity the difference between the pressures at two points is proportional to the difference of their depths.

   (c) In a fluid at rest under gravity horizontal planes are surfaces of equal density.

   (d) When two fluids of different densities at rest under gravity do not mix, their surface of separation is a horizontal plane.
   Pressure in heavy homogeneous liquid. Thrust of heavy homogeneous liquid of plane surfaces.

2. Definition of centre of pressure. Formula for the depth of the centre of pressure of a plane area. Position of the centre of pressure. Centre of pressure of a triangular area whose angular points are at different depths. Centre of pressure of a circular area. Position of the centre of pressure referred to co-ordinate axes through the centroid of the area. Centre of pressure of an elliptical area when its major axis in

vertical or along the line of greatest slope. Effect of additional depth on centre of pressure.

3. Equilibrium of fluids in given fields of force: Definition of field of force, line of force. Pressure derivative in terms of force. Surface of equi-pressure. To find the necessary and sufficient conditions of equilibrium of a fluid under the action of a force whose components are X, Y, Z along the co-ordinate axes. To prove (i) that surfaces of equal pressure are the surfaces intersecting orthogonally the fines of force. (ii) when the force system is conservative, the surfaces of equal pressure are equipotential surfaces and are also surfaces of equal density. To find the differential equations of the surfaces of equal pressure and density.

4. Rotating fluids. To determine the pressure at any point and the surfaces of equal pressure when a mass of homogeneous liquid contained in a vessel, revolves uniformly about a vertical axis.

5. Thurst on Curved Surface.

6. The stability of the equilibrium of floating bodies. Definition, stability of equilibrium of a floating body, metacentre, plane of floatation, surface of buoyancy. General propositions about small rotational displacements. To derive the condition for stability.

Reference Books

1. Besant and Ramsey: *Hydrostatics*.
2. S. L. Loney: *Hydrostatics.*
3. A. S. Ramsey: *Hydrostatics*.
4. J. M. Kar: *Hydrostatics*.
5. Bej and Mukherjee: *Hydrostatics.*

Group - C

Discrete Mathematics **Marks: 20**

1. Sets and Propositions: Cardinality, principle of inclusion and exclusion, connectives, Tautology and contradictions, equivalence formula.

2. Graph Theory: Graphs: undirected graphs, Directed graphs, basic properties, complete graph, complement of a Graph, bipartite Graphs, Necessary and Sufficient condition for a Bipartite Graph, Weighted Graphs, Walk, Path, Cycles, Circuit, Euler Graph, Konisberg Bridge Problem. Trees: Basic properties, spanning tree.

3. Partial order relations and Lattices: Definitions of poset, lattice, chain and anti-chain, properties of a lattice, distributive lattice with properties.

4. Discrete numeric functions and generating functions.

Reference Books

1. S. Lipschutz and M. L. Lipson: *Discrete Mathematics*.
2. R. Johnsonbaugh : *Discrete Mathematics*.
3. R. P. Grimaldi: *Discrete and Combinatorial Mathematics*.
4. K. H. Rosen: *Elements of Number Theory and its Applications*.
5. J. K. Sharma: *Discrete Mathematics*.
6. R. J. Wilson: *Introduction to Graph Theory*.
7. Babu Ram: *Discrete Mathematics*.

Group - D

Mathematical Modeling **Marks: 15**

1. Introduction, Basic steps of Mathematical modeling and its utility, preliminary concept of stability of differential equation.

2. Mathematical models with their formulation, solution, interpretation and limitations (i) Single species models (Exponential and Logistic growth), (ii) Two species population models (Two competing species and Prey-prediator).

3. Simple epidemic model (SI) with the formulation, solution, interpretation and limitations.

Reference Books

1. J. N. Kapur: *Mathematical Modelling*.
2. J. D. Murray: *Mathematical Biology*.
3. R. Illner, C. S. Bohun, S. McCollum and T. V. Roode: *Mathematical Modelling*.

Paper- VII

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Elements of Computer Science **Marks: 30**

1. Elementary computers programming: Concepts of machine language, assembly language, different high level languages and compilers. Application of computer programming: Different steps of solving a problem by a Computer. Computer oriented algorithm. Flowchart.

2. **Boolean Algebra and applications:**

   Binary arithmetic: binary numbers, binary-to-decimal conversion, decimal-to-binary conversion, Addition, subtraction, multiplication and division of binary numbers, Algebra of sets. Definition of Boolean algebra by Huntington postulates, Two elements Boolean algebra and other examples, principle of duality, basic theorems, Boolean functions, truth table, disjunctive and conjunctive normal forms, Theorem on construction of a Boolean function from a truth table and examples. Different binary operations and operators: AND, OR, NOT, NAND, NOR. Bistable devices, Logic gates-AND, OR, NOT, NAND, NOR (including block diagram and input-output table). Logic gates representations for Boolean expressions, Binary half adder and full adder.

3. **Programming Languages: Either FORTRAN 77 or ANSI C**

   FORTRAN 77: Fixed and floating point modes, constants and variables, subscripted variables, arithmetic expression, library functions, statements, and arithmetic, input, output and control statements. Arithmetic assignment statement, GO TO, Arithmetic IF, Logical IF, BLOCK IF, DO, CONTINUE, READ, WRITE, PRINT, STOP, END, DIMENSION and FORMAT (List directed, I, E, F, X and H specification only). Two dimensional arrays, arithmetic statement, functions subprogram, subroutine subprogram. strings.

   ANSI C: Character set in ANSI C. Key words: if, while, do, for, int, char, float, etc. Data type: character, integer, floating point, etc. Variables, Operators: =, == ,

!, < > , etc. (arithmetic, assignment, relational, logical, increment, etc.). Expressions: arithmetic and logical expressions. Standard input/output. Use of while, if-else, for, do - while, switch, continue, etc. Arrays, strings, user defined function. Header File.

4. The various problems on Mathematics are to be studied during programming in FORTRAN 77 or in C:

Reference Books

1. D. M. Etter: *Structured FORTRAN 77 for Engineers and Scientists*.
2. M. Pal: *FORTRAN 77 with Numerical and Statistical Analysis*.
3. C. Xavier: *FORTRAN 77 and Numerical Methods*.
4. Y. Kanetkar: *Let us C.*
5. E. Balagurusamy: *Programming in ANSI C.*
6. C. Xavier: *Programming in C.*
7. Srivastava and Srivastava: *C in Depth*.
8. M. Pal, *Programming in C with numerical and Statistical Methods*.

Group – B

Mathematical Theory of Probability **Marks: 35**

Concepts of mathematical probability, Random experiments, The idea of probability as a long run relative frequency. Sample space, mutually exclusive events, exhaustive events. Union of events, intersection of events, Kolmogorov's axiomatic definition of probability, classical definition as a special case of the axiomatic, theorems on the probability of the union of an events. Theorem of total probability, Boole's inequality, conditional probability, theorem of compound probability, theorem of inverse probability (Baye's theorem). Statistical independence of events, independent trials, random variables, discrete and continuous distributions, probability distribution function, expectation, variance, moments of a random variable, basic ideas of moment generating function (m.g.f.) and characteristic function, dependent and independent trials. Bernoulli's trials, Binomial law, Joint distribution of two random variables and transformation of variables.

Marginal and conditional distributions, Sum law and product law of expectation, two dimensional expectation and conditional expectation, Correlation and regression.

Tchebycheff's inequality, convergence in probability, Bernoulli's limit theorem, weak law of large numbers. Central limit theorem (statement only). Poissons approximation to Binomial distribution, Normal approximation to Binomial distribution.

Detailed understanding of hyper-geometric binomial, negative binomial and Poisson distributions and (b) rectangular, gamma, beta and normal distributions, x^2 and t distributions.

Reference Books

1. A. Gupta: *Ground Work of Mathematical Probability and Statistics*.
2. A. P. Baisnab and M.S. Jas: *Mathematical Probability and Statistics*.
3. W. Fellar: *An introduction to Probability Theory and its applications*.
4. H. Cramer: *The Elements of Probability Theory and some of its Applications*.
5. J. V. Uspensky: *Mathematical Probability*.
6. Bannerjee, Dey and Sen: *Mathematical Probability*.
7. Ross: *First Course in Probability*.

Group – C

Mathematical Statistics **Marks: 25**

Collection of data, Tabulation and graphical representation of data, Qualitative and quantitative characteristics of discrete and continuous variables, Frequency table and its graphical representation. Measures of central tendency: mean (simple and weighted), median mode. Measures of dispersion: range, mean deviation and standard deviation, coefficient of variation, moments, skewness and kurtosis.

Random sampling, sampling distribution of a statistic. Sampling distribution of a sample means (normal population case) and sample proportion.

Statistical inference. Point estimation of a parameter unbiased and consistent estimates. Method of maximum likelihood.

Bivariate data, Scattered diagram, simple correlation and regression, curve fitting (linear and parabolic).

Statistical hypothesis: Simple and composite, critical region of a test. Type-I and Type-II error.

Confidence interval and confidence coefficients: Confidence interval for a single variance (normal distribution), Neyman-Pearson theorem (statement only). Testing of Hypothesis (large and small sample, Normal distribution only).

Reference Books

1. H. Cramer: *Mathematical method of Statistics*.
2. Dey & Sen: *Mathematical Statistics*.
3. Kapoor and Saxena: *Statistics*.
4. A. Gupta: *Ground work of Mathematical Probability and Statistics*.
5. Gupta and Kapoor: *Mathematical Statistics*.

Paper - VIII

(Marks: 100, No. of Lectures: 150, Tutorials: 40)

Group - A

Numerical Analysis **Marks: 25**

1. Basic concepts: approximation of numbers, significant figures, absolute, relative and percentage errors, truncation and round off errors, accumulation and propagation of errors.

2. Polynomial interpolation and application: Lagrangian interpolation problem. Linear interpolation formula. Lagrange's formula.

3. Differences: Forward, backward and divided difference tables, linear difference equations with constant coefficients. Newton's general interpolation formula with remainder term, Newton's forward and backward formulae, error in these formulae. Numerical differentiation based on Newton's forward and backward formulae.

4. Numerical integration: Newton's Cotes formulae, trapezoidal rule, Simpson's one-third rule and inherent errors, Weddle's rule, Summation of finite series by Euler-Maclaurin series (statement only).

5. Solution of equations (algebraic and transcendental) : Solution of a single equation by –
    i. Graphical method,
    ii. Method of bisection,
    iii. Regula falsi method,
    iv. Fixed point iteration method,
    v. Newton-Raphson method.

   Geometrical interpretation of these methods. Convergence of fixed-point iteration and Newton-Raphson method.

6. Gauss-elimination, Gauss-Siedal method for the solution of a system of linear equations.

7. Solution of differential equations: Solution of a first order differential equation by Euler's method and modified Euler's method. Runga-Kutta (2nd and 4th order) methods (emphasizing the problem only).

Reference Books

1. F. B. Hilderbrand: *Introduction to Numerical Analysis*.
2. M.K. Jain, S. R K. Iyenger and R.K. Jain: *Numerical Methods for Scientific Computations.*
3. S. S. Sastri : *Numerical Analysis*.
4. N. Datta and R.N. Jana: *An introduction to Numerical Analysis*.
5. S. A. Mollah: *Numerical Analysis and Computational Procedures*.
6. M. Pal: *Numerical Analysis for Scientists and Engineers*.

Group - B

Real Analysis – III **Marks: 25**

1. Real Valued functions defined on a subset (may not be an interval) of real numbers; limit of a real-valued function at a limit point of the domain (subset of *R)* of the functions, sequential and Cauchy's criteria for the existence of a limit of a function at a point. Algebra of limits in this context.

2. Continuity of a function at a point on a subset of *R,* Sequential criteria for continuity at a point, continuity on a set. Algebra of continuous functions as a consequence of algebra of limits, continuity of composites of continuous functions. Uniform continuity on a set. If f is continuous on a closed and bounded subset of R, then f is uniformly continuous there. If f is uniformly continuous on a subset of real numbers then it is uniformly continuous on the closure of S.

3. Sequence of functions: Pointwise and uniform convergence, Cauchy's criteria for Uniform convergence, Weierstrass M-test, boundedness, continuity, differentiability and integrability of the limit function in case of uniform convergence.

4. Series of functions: Pointwise and uniform convergence, Cauchy's criteria for uniform convergence, Boundedness and continuity of the sum function in case of uniform convergence. Term by term integration and differentiation. Weierstrass M-test for uniform and absolute convergence.

5. Power series: Cauchy-Hadamard theorem, Radius of convergence, uniform convergence of power series and their related properties, uniqueness of a power series.

6. Fourier series. Dirichlet's condition of convergence at a point. Full range and half range series.

Reference Books

1. T. M. Apostol: *Calculus-I*.
2. W. Rudin: *Principles of Mathematical Analysis*.
3. Courant and John: *Differential and Integral Calculus (Vol. I and Vol. II)*.
4. Philips: *A Course of Analysis*.
5. R. G. Bertle and D. R. Sherbert: *Introduction to Real Analysis*.
6. Goldberg: *Methods of Real Analysis*.
7. Shanti Narayan: *Mathematical Analysis*.
8. Shanti Narayan: *Differential Calculus*.
9. Shanti Narayan: *Integral Calculus*.
10. Malik and Arora: *Mathematical Analysis.*
11. K. Knopp: *Theory and Applications of Infinite Series*.
12. Maity and Ghosh: *Integral Calculus*.
13. Mapa: *An Introduction of Real Analysis.*
14. Maity and Ghosh: *Different al Calculus, An Introduction to Analysis*.

Group – C

Linear Algebra-II **Marks: 10**

Linear Transformation on Vector spaces: Definition, Null space, range space, rank and nullity, Sylvester's law, simple applications, non-singular linear transformation, inverse of linear transformation. An (m x n) real matrix as a linear transformation from R^n to R^m.

Reference Books

1. K. B. Datta: *Matrix and Linear Algebra*.
2. Hoffman and Kuntze: *Linear Algebra*.
3. S .H. Friedberg, A.J. Insel and L.E. Spence: *Linear Algebra*.
4. Saikia: *Linear Algebra.*
5. Shanti Narayan: *A Text Book of Matrices*.
6. S. K. Mapa: *Higher Algebra (Abstract and Linear).*
7. Hadley: *Linear Algebra*.
8. Roo and Bhimasankaran: *A Text book of Linear Algebra*.

Group-D

(Classes per week: 3 periods)

Computer Practical **Marks: 30**

List of programs using FORTRAN or C

1. General programs

   (i) Area of circle, triangle, (ii) Summation of finite and convergent infinite series, (iii) Maximum and minimum among three number and n numbers, (iv) Roots of a quadratic equation, (v) G.C.D. and L.C.M. between two integers, (vi) Testing of prime numbers, (vii) Split a number into digits, (vii) Computation of ${}^nP_r$ and ${}^nC_r$, (viii) Searching and sorting (bubble sort only).

2. Problems on matrices

   (i) Addition and subtraction, (ii) Product, (iii) Trace and (iv) Transpose.

3. Problems on strings

   (i) Counting of words in a string, (ii) Palindrome testing, (iii) Conversion from upper case to lower case and lower case to upper case, (iv) Sorting of names, (v) Rewrite name of a person in short form, (vi) searching a sub-string among a set of strings.

4. Problems on Numerical Methods
   (i) Interpolation by Lagrange's and Newton forwards difference methods, (ii) Finding of roots by bisection, regula-falsi, fixed point iteration and Newton-Rapshon methods, (iii) Integration by trapezoidal and Simpson 1/3 rule, (iv) Solution of a system of equations by Gauss-Siedal method, (v) Solution of a differential equation by Runge-Kutta methods.

5. Problems on Statistical methods
   (i) Preparation of grouped frequency table, (ii) Mean, median and mode for simple and grouped frequency distribution, (iii) Standard deviation, mean deviation, (iv) Moments, skewness and kurtosis, (v) Correlation and regression, (vi) Fitting of straight and parabolic curve.

Reference Books

1. D. M. Etter: *Structured FORTRAN 77 for Engineers and Scientists*.
2. M. Pal : *FORTRAN 77 with Numerical and Statistical Analysis*.
3. C. Xavier: *FORTRAN 77 and Numerical Methods*.
4. Y. Kanetkar: *Let us C*.
5. E. Balagurusamy: *Programming in ANSI C*.
6. M. Pal, *Programming in C with numerical and Statistical Methods*.

MATHEMATICS
(General Course)

PART-I
Paper - I:

Group A (Marks 25) : Classical Algebra
Group B (Marks 20) : Modern Algebra
Group C (Marks 30) : Analytical Geometry
Group D (Marks 15) : Vector Algebra
Internal Assessment (Marks 10)

PART-II
Paper -II:

Group A (Marks 45) : Differential Calculus
Group B (Marks 30) : Integral Calculus
Group C (Marks 15) : Differential Equations
Internal Assessment (Marks 10)

Paper -III:

Group A (Marks 35) : Linear Programming
Group B (Marks 20) : Numerical Analysis
Group C (Marks 35) : Analytical Dynamics
Internal Assessment (Marks 10)

PART-III
Paper -IV:

Group A (Marks 45) : Elements of Computer Science
Group B (Marks 45) : Probability and Statistics
Internal Assessment (Marks 10)

PART I

Paper-I

(Marks: 100, No. of Lectures: 100, Tutorials: 50)

Group – A

Classical Algebra **Marks: 25**

1. De-Moivre's theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number, definition of a^z ($a \neq 0$) and hyperbolic functions.

2. Polynomials with real coefficients: Division algorithm, fundamental theorem of classical algebra (no proof required), n-th degree polynomial equation has exactly n roots. Nature of roots of an equation (surd or complex roots occur in pair). Statements of Descartes' rule of sign and its applications. Relations between roots and co-efficients, symmetric functions of roots, transformation of polynomial equation. Cardan's method of solution of a cubic equation, solution of biquadratic equation by Ferrari's method.

3. Determinants: Properties, co-factors and minors, reduction of determinants, product of two determinants, adjoint and inverse of a determinant, symmetric and skew symmetric determinants.

4. Matrices of real numbers: Equality of matrices, addition of matrices, multiplication of a matrix by a scalar. Multiplication of matrices-distributive, associative properties. Transpose of matrix-its properties. Square matrices. Symmetric, skew symmetric matrices, scalar matrices, identity matrix, inverse of a non-singular scalar matrix. Orthogonal matrix, rank of a matrix, determination of rank, solution of a system of linear equations with not more than three variables by matrix method (not involving ranks).

Group – B

Modern Algebra **Marks: 20**

1. Revision of Basic set theory, Cartesian product of two sets, Mappings, One-to-one and onto mappings, Composition of Mappings, Binary operation on a set.

2. Group-definition and examples taken from various branches (examples from number system roots of unity, 2 x 2 real matrices, non-singular real matrices of a fixed order). Elementary properties using the definition of group. Definition and examples of sub groups, cyclic groups, permutation-even and odd permutation, group of permutation.

3. Definition and examples of ring, sub-ring. Integral Domain. Division of zero. Every field is an integral domain. Field, sub-field.

4. Characteristic equation of a square matrix of order not more than three, determination of Eigen values and Eigen vectors - problems only. Statement and illustration of Cayley - Hamilton theorem.

Group – C

Analytical Geometry of Two and Three Dimensions **Marks: 30**

1. Two dimensions: Polar equations of straight lines and circles, Polar equation of a conic referred to a focus as pole, equations of chord; tangent and normal. Transformations of rectangular axes: Translation, rotation and their combinations. General equation of second degree in two variables and its reduction to canonical (normal) forms. Classification of conics and their equations in canonical forms. Pairs of straight-lines: Condition that the general equation of second degree may represent two straight lines. Point of intersection of two intersecting straight lines, angle and angle bisectors between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equations of two straight lines joining the origin to the points in which line meets a conic.

2. Three dimensions: Rectangular Cartesian co-ordinates in space, the concept of a geometric vector (free vector). Projections of a vector on co-ordinate axes, Division of a line segment in a given ratio, direction cosines, and direction ratios of a straight line. Angle between two straight lines. Area of a triangle. The equation of a surface and the equation of a curve. Equation of a plane: General form, intercept and normal form, angle between two planes, signed distance of a point from a plane. The straight line in space: Its equation in symmetric (canonical) and parametric forms. Conditions for the parallelism and the perpendicularity of two planes, of two straight lines and of a straight line and a plane, Distance between two skew straight lines, coplanarity of two straight lines. The sphere, tangent and normal. The cone. The cylinder.

Group – D

Vector Algebra **Marks: 15**

Collinear and coplanar vectors, scalar and vector product of two vectors, scalar triple product of three vectors and its geometrical interpretation, simple application to geometry. Vector equations of straight lines and planes.

Reference Books

1. Ghosh and Chakraborty: *Higher Algebra*.
2. S. K Mapa: *Higher Algebra (Abstract and Linear)*.
3. M.K. Sen, P. Mukhopadhyay and S. Ghosh: *Topics in Abstract Algebra*.
4. Bernard and Child: *Higher Algebra*
5. Burnside and Panton: *Theory of Equations (Vol. I)*.
6. D. S. Malik, J.M. Mordeson and M.K. Sen: *Fundamentals of Abstract Algebra*.
7. K. B. Datta: *Matrix and Linear Algebra*.
8. Shanti Narayan: *A Text Book of Matrices*.
9. B. K. Das: *Higher Algebra*.
10. M. C. Chaki: *A text book of Analytic Geometry*.
11. N. Datta and R.N. Jana: *Analytical Geometry*.
12. Ghosh and Chakraborty: *Analytical Geometry*.
13. R.M. Khan: *Analytical Geometry*.

14. Maity and Ghosh: *Vector Analysis*.
15. M. Pal, *Advanced Algebra*.

Paper-II

(Marks: 100, No. of Lectures: 100, Tutorials: 40)

Group - A

Differential Calculus **Marks: 45**

1. Concept of rational number, Irrational number, Real number.

2. Sequence of numbers, concept of limit of a sequence, Null sequence, Bounded sequence, Monotonic sequence, supremum and infimum of a sequence; A convergent sequence is bounded and has a unique limit, Bounded and monotonic sequence is convergent.

$$e = \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$$

   Statement of the theorems on limits of sequence, Cauchy sequence, Statement of Cauchy's general principle of convergence, simple problem.

3. Infinite series of constant term: Definition of convergence and divergence, Cauchy's convergence Principle (application only), Geometric series and p-series and their convergence (Only statement). Series of non-negative terms: Statement of comparison test. D' Alembert ratio test, Cauchy's nth root test and Raabe's test. Simple applications.

4. Function of a single real variable defined on an interval, their graphs, Algebra of limits and continuity (no proof). Definition and acquaintance (no proof required) with the properties of continuous function on closed intervals, statement and existence of inverse function of a strictly monotonic function and its continuity.

5. Derivatives - its geometric and physical interpretation, rule of differentiation (a revision of previous knowledge only). Differential its geometrical interpretation

and application in finding approximations, relation between continuity and derivability.

6. Successive derivatives, Leibnitz theorem: increasing and decreasing functions, sign of the derivatives, statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange's, its geometrical interpretation, Cauchy's mean value theorem. Taylor's and Maclaurin's theorems with Cauchy's and Lagrange's form of remainder (statement only). Expansion in power of x with infinite series for such functions as $exp(x)$, $sin(x)$, $cos(x)$, $(1+x)^n$, $log(1+x)$ (with restrictions wherever necessary). Indeterminate form, L'Hospital's rule, maxima and minima (Differentiations and acquaintance with rules of finding extreme, emphasis on solving problems only).

7. Function of two variables, their geometrical interpretation, limit, repeated limit and continuity (definitions and examples only). Partial differentiation, knowledge of chain rules, Exact differential, Differentiation of implicit functions, successive partial derivatives, statement of Schawarz's theorem on the commutative property of mixed partial derivative, Euler's theorem on a homogeneous function of two variables.

8. Applications: Problem on
   (i) Tangent and normals.
   (ii) Rectilinear asymptotes of algebraic curves,
   (iii) Curvature and radius of curvature of plane curves,
   (iv) Envelope of family of straight lines.

Group - B

Integral Calculus **Marks: 30**

1. Indefinite Integration: Standard form, Methods by substitution and Integration by parts (Revision of previous knowledge). Integration of rational function and trigonometric function.

2. Definite Integral as the limit of sum, Geometrical interpretation of definite Integrals of bounded continuous functions, Fundamental theorem of integral calculus, Properties of definite integral and their applications.

3. Reduction formula of $\int_0^{\pi/2} sin^m xdx$, $\int_0^{\pi/2} cos^n\, xdx$, $\int_0^{\pi/2} sin^m\, x\, cos^n xdx$, $\int_0^{\pi/2} tan^n\, xdx$ and associated problems (*m* and *n* are non-negatives).

4. Definition of improper integrals, working knowledge of Beta and Gamma functions (convergence and important relations being assumed).

5. Working knowledge of double and triple integrals, Jacobian.

6. Application: Rectification (formation of intrinsic equations from cartesian and polar equation). Quadrature, Volumes and surface area of solids formed by revolution of curves and areas.

Group - C

Differential Equations **Marks: 15**

1. First order linear and non-linear differential equations, application in simple geometrical problems.
2. Second order linear differential equations with constant coefficient, linear homogeneous second order differential equations.
3. Simultaneous linear differential equation with constant coefficients up to second order.
4. Simple Eigen value problems.

Reference Books

1. *Differential Calculus*: Das and Mukherjee.
2. Shanti Narayan: *Differential Calculus*.
3. Das and Mukherjee: *Integral Calculus*.
4. Shanti Narayan: *Integral Calculus*.
5. Maity and Ghosh: *Integral Calculus*.
6. Chakraborty and Ghosh: *Differential Equations*.
7. Maity and Ghosh: *Differential Equations*.

Paper-III

(Marks: 100, No. of Lectures: 100, Tutorials: 40)

Group-A

Linear Programming **Marks: 35**

Inequation, definition of linear programming, problems bringing an objective function amongst set of constraints involving inequations. Formation of simple L.P. problems from day to day life, solution of L.P.P. by graphical method, linear dependence of vectors. Basic solutions and basic feasible solutions with reference to L.P.P., Degenerate and non-degenerate B. F. S., hyper-plane, convex set, extreme points, convex hyper-plane and statement of relevant theorems. Statement of the fundamental theorem of L.P.P.

Reduction of a F. S. to a B. F. S., Transformation of inequations to equations by slack and surplus variables. Simplex method (without proof), Feasibility and optimality conditions. The algorithm, simple application from daily life. Big-M method, Duality theory, The dual of the dual is primal. Definition of Transportation problem and assignment problem and their connection with L.P.P., algorithmic solution of T.P. and A.P. (no proof is required), simple applications.

Group-B

Numerical Analysis **Marks: 20**

1. Polynomial interpolation and applications: Lagrangian interpolation problem. Linear interpolation formula. Lagrange's formula.

2. Differences: Forward, backward and divided difference tables. Newton's general interpolation formula with the remainder term, Newton's forward and backward formulae, error in these formulae, Numerical differentiation based on Newton's forward and backward formulae.

3. Numerical integration: Newton's-Cotes formula, trapezoidal rule, Simpson's one-third rule and inherent errors.

4. Solution of equations (algebraic and transcendental) : Solution of a single equation by
   (i) Graphical method.
   (ii) Bisection method.
   (iii) Regula falsi method.
   (iv) Iteration method.
   (v) Newton-Raphson method.

Geometrical interpretation of these methods. Convergence of Iteration- and Newton-Raphson method.

Group – C

Analytical Dynamics **Marks: 35**

Impulse and impulsive forces, work, power and energy, principles of conservation of energy and momentum, collision of elastic bodies (loss of K.E. to be calculated in the case of direct of impact only).

Motion in a straight line under variable forces, damped, forced and damped forced vibration, motion under inverse square law. Velocity and accelerations of a panicle in cartesian and polar co-ordinates. Tangential and normal accelerations, circular motion. Motion in a plane, equations of motion in cartesian and polar coordinates, central orbits, escape velocity.

Reference Books

1. J. G. Chakraborty and P.R. Ghosh: *Linear Programming and Game Theory*.
2. P. M. Karak: *Linear Programming*.
3. F. B. Hilderbrand: *Introduction to Numerical Analysis*.
4. N. Datta and R.N. Jana, *An Introduction to Numerical Analysis*.
5. S. A. Mollah: *Numerical Analysis and Computational Procedures*.
6. M. Pal: *Numerical Analysis for Scientists and Engineers*.
7. S. L. Loney: *An Elementary Treatise on the Dynamics of a particle and of rigid bodies.*
8. J. G. Chakraborty and P. R. Ghosh: *Advanced Analytical Dynamics*.
9. N. Datta and R. N. Jana: *Dynamics of a Particle*.
10. Das and Mukherjee: *Analytical Dynamics*.
11. S. R. Maity: *Dynamics of a Particle*.

PART II
Paper-IV

(Marks: 100, No. of Lectures: 100, Tutorials: 50)

Group - A

Elements of Computer Science **Marks: 45**

Computers and their functions and programming:

Computers and their function: Information processing. History of data processing machines. Digital Computer, components and their functions and interactions input: storage, control, arithmetic logic and output systems, analogy between the working of a clerk and computer, analog and digital computers. Punched cards and different input / output media applications computers.

Elementary Computers Programming: Concepts of machine language, assembly language, different higher level languages and compilers, Fixed and floating point models, constants and variables, subscripted variables, arithmetic expression, Library functions, FORTRAN - 77 : Statements, arithmetic, input, output and control statements. Arithmetic assignment statement, GO TO, Arithmetic IF, Logical IF, BLOCK IF, DO, CONTINUE, READ, WRITE, PRINT, STOP, END, DIMENSION and FORMAT (List directed, I, E, F, X ,and H specification only). Two dimensional arrays, Date cards.

Applications of computer programming: Different steps of solving a problem by a computer.

Computer oriented algorithm. Flow-chart. Writing on a coding sheet and computer programmes in FORTRAN for the solution of simple computational problems including problems:

(i) Evaluation of functions,
(ii) Solutions of quadratic equation,
(iii) Determination of the approximate sum of convergent infinite series sorting.
(iv) Finite set of numbers in ascending and descending order,
(v) Solution of equations by iteration and Newton-Raphson method,

(vi) Numerical integration by Simpson's one third rule.

Boolean Algebra and Applications:

Binary arithmetic-binary numbers, binary-to-decimal conversion, Decimal-to-binary conversion. Addition, Subtraction, Multiplication and Division of binary numbers. Definition of Boolean algebra by Huntington postulates. Two element Boolean algebra and other examples. Principle of Duality. Basic theorems, Boolean functions. Truth table, Disjunctive and conjunctive normal forms. Theorems on construction of a Boolean function from a truth table and examples. Different binary operations and operators. AND, OR, NOT, NAND, NOR. Bistable devices, Logic Gates-AND, OR, NOT, NAND, NOR (including block diagram and input-output table). Logic Gates representations for Boolean expressions.

Reference Books

1. M. Pal : *FORTRAN - 77 with Numerical and Statistical Analysis*.
2. C. Xavier: *FORTRAN - 77 and Numerical Methods*.

Group – B

Probability and Statistics **Marks: 45**

Elements of Probability Theory: Random experiments, Statistical regularity and idea of probability as long run mutually exclusive event and exhaustive events, union, Intersection and complement, classical definition of probability, axiomatic approach of probability theory (detailed treatment not required), theorem on the union of a number of events, conditional probability, theorem of total probability and Bayes' theorem, independent event and independent trials, random variable and its probability distribution, expectation and variance. Joint, marginal and conditional distribution.

Elements of Statistics: Qualitative and quantitative characters. Discrete variable and continuous variable, frequency distribution and its graphical representation, measures of central tendency (mean median and mode), measures of dispersion (range, mean deviation and standard deviation), Skewness and Kurtosis, moments and β_1 and β_2 coefficients. Binomial, Poisson and normal distribution. Correlation and regression. Estimation of parameters, maximum likelihood method, interval estimation.

Reference Books

1. A. Gupta: *Ground Work of Mathematical Probability and Statistics*.
2. A. P. Baisnab and M.S. Jas: *Mathematical Probability and Statistics*.
3. Banerjee, Dey and Sen: *Mathematical Probability*.
4. Dey & Sen: *Mathematical Statistics*.
5. Kapoor and Saxena: *Statistics*.