B.Sc. I
MATHEMATICS

Paper I

Algebra

Mapping , Equivalence Relations and partitions , Congruence Modulo n ,Symmetric , Skew symmetric , Hermitian and Skew Hermitian Matrices , Elemen tary Operations on Matrices, Invers of a matrix .Linear independence of row and column matrices .Row rank , Column Rank and Rank of a matrix .Equivalence of Column and Row Ranks. Eigen values , eigen vectors and the characteristic equation of a matrix. Cayley Hemilton Theorem and its use in finding inverse of a matrix. Application of matrices to a system of linear (both homogeneous and non- homogeneous) equations.Theorems on consistency of a system of Linear equations. Relations between the roots and coefficients of a general polynomial equation in one variable.Transformation of equations. Descarte's Rule of Signs.Solution of Cubic equations (Cardon's Method) , biquadratic equations. Definition of a Group with examples and simple properties. Subgroup. Generation of Groups. Cyclic Groups.Coset Decomposition. Lagrange's Theorem and its consequences. Fermat's and Euler's Theorems. Homomorphism and Isomorphism. Normal Subgroups. Quotient Groups. The Fundamental Theorem of Homomorphism.Permutation Groups. Even and Odd Permutations. The Alternating Groups.and Cayley's Theorem. Automorphism, Inner automorphism, Automorphism Groups and their compositions. Conjugacy Relation. Normaliser. Counting Principle and the Class equation of a finite group. Centre for Group of prime order. Abelianising of a Group and its universal property. Sylow's Theorems. p-Sylow Group. Structure Theorem for finite abelian groups. Introduction to Rings, Subrings , Integral Domain and Fields . Characteristic of a Ring. Trigonometry De Moivre's Theorem and its applications.Direct and Inverse Circular and Hyperbolic functions.Logarithm of a complex quantity. Expansion of Trigonometrical Functions. Gregory's Series. Summation of Series.

Paper II

Differential Calculus

ε-δ definition of the limit of a function. Basic properties of limits. Continuous functions and classification of discontinuties. Differentiability. Successive Differentiation.Leibnitz's Theorem. Maclaurin's and Taylor's series expansion. Asymptotes.Curvature. Test for Concavity and Convexity . Points of Inflexion. Multiple Points. Tracing of Curves in Cartesian and Polar Coordinates.

Integral Calculus

Integration of irrational algebraic functions and transcedental functions. Reduction Formulae. Definite Integrals. Quadrature. Rectification. Volumes and Surfaces of solids of revolution.

Ordinary Differential Equations

Degree and Order of a differential equation.Equations of first order and first degree.Equations in which the variables are seperable.Homogeneous equations.Linear equations and the equations reducible to Linear Form.Exact differential Equation.First Order higher degree equations solvable for x, y , p.Clairaut's Form and Singular Solutions.Geometric Meanings of a differential equation. Orthogonal Trajectories.Linear Differential Equations with Constant Coefficients.Homogeneous Linear ordinary differential equation. Linear Differential Equations of the Second Order. Transforma tion of the equation by changing the dependent variable/ independent variable. Method of variation of parameters. Ordinary Simultaneous Differential Equations.

Paper III

Vector Analysis & Geometry

Scalar and Vector product of three vectors. Product of Four vectors. Reciprocal vectors. Vector Differentiation. Gradient , Diver gence and Curl .Vector Integration. Theorems of Gauss , Green , Stokes and problems based on these. General equation of Second Degree.Tracing of Conics. System of Conics. Confocal Conics. Polar equation of a Conic. Plane .The straight line and the plane. Sphere. Cone. Cylinder. Central Conicoids. Paraboloids. Plane Sec tions of Conicoids. Generating Lines. Confocal Conicoids. Reduction of Second Degree Equations.

B.Sc. II

Paper – I

Advance Calculus

Continuity , Sequential Continuity , Properties of continuous functions , Uniform Continuity, Chain Rule of Differentiability. Mean Value Theorems and their geometrical interpretations. Darboux's Intermediate Value Theorem for derivatives. Taylor's Theorem with various forms of remainders. (10 Marks) Limit and Continuity of functions of two variables.Partial Differentiations, Change of Variables. Euler's Theorem on Homogeneous functions. Taylor's Theorem for functions of two variables. Jacobians. (10 Marks) Envelopes , Evolutes , Maxima Minima and Saddle points of functions of two variables. Lagranges Multiplier Method, Indeterminate Forms. (10 Marks) Beta and Gamma Functions. Double and Triple integrals, Dirichilet's Integrals, Change of Order of integration in Double integrals. (10 Marks) Definition of a sequence . Theorems on limits of Sequences. Bounded and Monotonic Sequences. Cauchy's Convergence Criterion. Series of Non - negative terms. Comparision Test, Cauchy's Root Test , Ratio Test , Raabe's Test , Logarithmic Test , DeMorgan's and Bertrand's Test , Alternating Series. Leibnitz's Theorem. Absolute and Conditional Convergence. (10 Marks)

PAPER – II

(Differential Equation)

Series Solution of differential equations, Power Series Method, Bessel and Legendre and Hypergeometric equations. Bessel and Legendre and Hypergeometric Functions and their properties, Recurrence and Generating Relations, Orthogonality of Functions , Sturm Liouville Problem. Orthogonality of Eigen Functions.Reality of Eigen values. Orthogonality of Bessel's Functions and Legendre's Polynomials. (10 Marks) Laplace Transformation, Linerarity of the Laplace Transformation. Existence theorem of Laplace Transformation. Laplace Transforms of Derivatives and Integrals. Shifting Theorems.Differentiation and Integration of transforms. Convolution Theorem. Solution of Integral Equations and System of differential equations using Laplace Transfor. (10 Marks) Partial Differential equations of the first order. Lagrange's Solution. Some Special types of equations which can be solved easily by methods other than the general method. Charpit's General Method of solution. Partial differential equations of Second and higher orders. Classifications of Linear Partial Differential equations of second order. Homogeneous and Non homogeneous equations with constant coefficients. Partial differential equations reducible to equations with constant coefficients .Monge's Methods. (10 Marks) Calculus of Variations, Variational Problems with fixed boundaries. Euler'e Equation for functionals containing first order derivative and one independent variable. Extrernals. Functionals dependent on higher order derivatives. Functionals dependent on more than one independent variable. Variational problems in parametric form. Invariance of Euler's equation under coordinates transformation. (10 Marks) Variational Problems with Moving Boundaries, Functionals dependent on one and two functions. One sided variations. Sufficient conditions for an Extremum , Jacobi and Legendre Conditions. Second Variation Principle of Least action. (10 Marks)

PAPER – III

(Mechanics)

Statistics : Analytical conditions of equilibrium of Coplanar forces, Virtual Work , Catenary. Forces in three dimensions, Poinsot's CentralAxis, Wrenches , Null Lines and Planes, Stable and unstable Equlibrium. (20 Marks) Dynamics : Velocities and Accelarations along radial and transverse directions and alond tangential and Normal directions. Simple Harmonic Motion. Elastic Strings. Motion on smooth and rough plane curves, Motion in a resisting medium, Motion of particle of

varying mass. Central Orbits , Kepler's Laws of Motion. Motion of particle in three dimendions, Accelaration in terms of different coordinate systems. (30 Marks)

B.Sc.III

PAPER – I

(Analysis)

Real Analysis : Riemann Integral, Integrability of continuous and monotonic functions.The Fundamental Theorem of Integral Calculus. Mean Value Theorems of Integral Calculus. Improper Integrals and their convergence, Comparision Test, Abel's and Dirichilet's Tests. Frullani's Integral. Integral as the sum of a parameter. Continuity, Derivability and integrability of an integral of a function of a parameter. Series of arbitrary terms. Convergence, Divergence and Oscillation. Abel's and Dirichilet's Tests. Multiplication of series. Double Series.Partial Derivation and Differentiability of real valued functions of two variables. Schwart's and Young's Theorem. Implicit Function Theorem. Fourier Series. Fourier expansion of Piecewise Monotonic Functions.(25 Marks) Complex Analysis : Complex Numbers as Ordered Pairs. Geometric Representation of Complex Numbers. Stereographic Projection. Continuity and Differentiability of Complex Functions,Analytic Functions, Cauchy Riemann's Equations. Harmonic Functions. Elementary Functions. Mapping by elementary functions. Mobius Transformations. Fixed Points. Cross Ratio. Inverse Points and Critical Mappings. Conformal Mappings. (30 Marks) Metric Spaces : Definition and examples of Metric Spaces. Neighbourhoods. Limit Points. Interior Points . Open and Closed Sets. Closure and Interior. Boundary Points. Subspace of a Metric Space. Cauchy's Sequence. Cantor's Intersection Theorem. Contraction Principle. Construction of Real Numbers as the Completion of the Incomplete Metric Space of rationals. Real numbers as a Complete Ordered Field.Dense subsets.Baire Category Theorem. Separable ,Second Countable and First Countable Spaces. Continuous Functions. Extension Theorem. Uniform Continuity. Isometry and homomorphism. Equivalent Metrics. Compactness.Sequential Compactness.Totally Bounded Spaces. Finite Intersection Property. Continuous functions and Compact sets. Connectedness. Components. Continuous functions and connected sets. (20 Marks)

Paper– II

(Numerical Analysis)

Solution of Equations : Bisection , Secant ,Regula Falsi,Newton's Method, Roots of Polynomials. Interpolation : Lagranges and Hermite Interpolation. Divided Differences. Difference Schemes. Interpolation Formula using Differences. Numerical Differentiation .Numerical Quadrature. Newton Cote's Formulas. Gauss Quadrature Formula , Chebychev's Formulas . Linear Equations.Direct Methods for solving systems of linear equations (Gauss Elimination. LU decomposition, Cholesky Decomposition) ,Iterative Methods (Jacobi , Gauss Seidal , Relaxation Methods) The Algebraic Eigenvalue Problem .Jacobi's Method ,Given's Method , Householder's Method , Power Method , QR Method , Lanczos' Method. Ordinary Differential Equations. Euler Method, Single Step Methods, Runge-Kutta's Method , Multi Step Methods, Milne Simpson's Method , Methods based on Numerical Integration, Methods based on Numerical Differentiation, Boundary Value Problems, Eigenvalue Problems. Approximation. Different types of approximations, Least Square Polynomial approximation, Polynomial approximation using Orthogonal polynomials, Approximation with Trigonometric Functions. Exponential functions, Chebychev's Polynomial,Ratioal Functions. (55 Marks)

Monte Carlo Methods : Random Number Generation , Congruential Generators, Statistical Tests of Pseudo Random Numbers. Random Variate Generation ,Inverse Transform Method , Composition Method , Acceptance- Rejection Method,Generation of exponential, Normal Variates, Binomial and Poisson Variates.Monte Carlo Integration. Hit or Miss Monte Carlo Integration , Monte Carlo Integration for Improper Integrals. Error Analysis for Monte Carlo Integration. (20 Marks)

Paper– III (OPTIONAL)

1. Differential Geometry

Local Theory of Curves : Space Curves,Examples ,Planner Curves. Helices. Serret-Frenet Apparatus. Existence of Space Curves. Involutes and Evolutes of Curves. Global Theory of Curves : Rotation Index. Convex Curves. Isoperimetric Inequality. Four Vetex Theorem. Local Theory of Surfaces : Parametric Patches on Surface. First Fundamental Form and Arc Length. Normal Curvature. Geodesic Curvature and Gauss Formulae. Shap operator Lp of a surface at a point. Vector Field along a curve. Second and Third Fundamental Forms of the Surfaces. Weiengarten Map. Principal Curvatures. Gaussian Curvature. Mean and Normal Curvatures. Gauss Theorem egregium. Isometry Groups and the Fundamental Existence theorem of surfaces. (15 Marks)

Global Theory of Surfaces : Geodesic Coordinate Patches. Gauss Bonnet Formulae. Euler-Characteristic of a Surface. Index of a Vector Field. Spaces of Constant Curvature. (10 Marks) Intrinsic Theory of Surfaces in Riemannian Geometry. Parallel Translation and Connection. Cartan's Stuctural Equations and Curvature. Interpretation of Curvature. Geodesic Curvature and Gauss Bonnet for a 2 -Dimensional Riemman Surface. Geodesic Coordinate Systems. Isometries and Spaces of constant curvature and the 3-types of geometry. (10 Marks) Transic Extension Theory of Surfaces in R3- Spherical image. Parallel translation for imbedded surfaces in R3. Classification of Compact Connected Oriented surfaces in R3 relative to curvature. (10 Marks) Elements of General Riemannian Geometry. Concepts of Manifolds and examples. Riemannian Metric. Tensor Fields Covariant Differentiation. Symmetry properties of Curvature Tensor. Concept of Affine Connection. Christoffel's Symbols. Curvature and Torsion Tensors. Riemannian Metric and Affine Connection Geodesic and Normal coordinates.Fundamental Theorem of Riemannian Geometry. (15 Marks)

Paper– III (OPTIONAL)

2. Discrete Mathmatics

Sets and Propositions : Cardinality.Mathematical Induction. Principle of Inclusion and Exclusion. Computability and Formal Languages . Ordered Sets . Languages. Phrase Structure Grammars. Types of Grammars and Languages. (15 Marks) Permutations. Combinations and Discrete Probability. Relations and Functions. Binary Relations. Equivalence Relations and Partitions. Partial Ordered Relations and Lattices. Chains and Antichains. Pigeon Hole principle. (15 Marks) Graphs and Planar Graphs. Basic Terminology. Multigraphs. Weighted Graphs. Paths and Circuits. Shortest Paths and Circuits. Travelling Salesman Problem. Planar Graphs. Trees. (15 Marks) Finite State Machines. Equivalent Machines. Finite State Machines as Language Recognizers. Analysis of Algorithms. Time Complexity. Complexity of Problems Discrete Numeric Functions and Generating Functions. Recurrence Relations and Recursive Algorithms. Linear Recurrence Relations with constant coefficients. Homogeneous solutions. Particular Solution. Total Solution. Solution by Method of Generating Functions. (15 Marks) Brief Review of Groups and Rings Boolean Algebras. Lattices and Algebraic Structures. Duality. Distributive and Complemented Lattices. Boolean Lattices and Boolean Algebras. Boolean Functions and Expressions. Propositional Calculus. Design and Implementation of Digital Networks. Switching Circuits. (15 Marks)

Paper– III (OPTIONAL)

3. Mechanics

Dynamics of Rigid Bodies : Moments and Product of Inertia. The Momental Ellipsoid. Equimomental Systems. Principal Axes D'Alembert's Principle. The General Equations of Motion of a rigid body. Motion of the Centre of Inertia and Motion relative to the Centre of Inertia. Motion

about a Fixed Axis. The Compound Pendulum. Centre of Percussion. Motion of a rigid body in Two Dimensions under finite and impulsive forces. Conservation of Momentum and Energy .Lagrange's Equations. Initial Motions. (40 Marks) Hydrostatics : Pressure Equation. Condition of Equilibrium. Lines of Forces. Homogeneous and Hetrogeneous Fluids. Elastic Fluids. Surface of Equal Pressure. Fluid at rest under action of gravity. Rotating Fluids. Fluid Pressure on Plane Surfaces. Centre of Pressure. Resultant Pressure on Curved Surfaces. Equilibrium of Floating Bodies.Curves of Byoancy. Surface of Byoancy. Stability of Equilibrium of Floating bodies. Meta Centre. Work Done in producing a displacement. Vessel containing Liquid. Gas Laws. Mixture of Gases. Internal Energy. Adiabatic Expansion. Work Done in compressing a gas.Isothermal Atmosphere. Connective Equilibrium. (35 Marks)

Paper – III (OPTIONAL)

4. Mathematical Modelling

The Process of Applied Mathematics. Setting up First order Differential equations. Qualitative Solution Sketching. Difference and Differential Equation Growth Models.Single Species Population Models. Population Growth. An age structure Model. The spread of Technological Innovation. (15 Marks) Higher Order Linear Models. A model of Detection of Diabetes. Combat Modes. (12 Marks) Traffic Models. Car following Models. Equilibrium Speed Distributions. (12 Marks) Non Linear Population Growth Models. Prey-Predator Models. Epidemic Growth Models. (12 Marks) Models from Political Science. Proportional Representation. Cumulative Voting. Comparision Voting. (12 Marks) Application in Ecological and Environmental Subject ares. Urban

Paper – III (OPTIONAL)

5. APPLICATION OF MATHEMATICS
IN FINANCE & INSURANCE

Application of Mathematics in Finance\ Financial Management : An Overview. Nature and Scope of Financial Management. Goals of Financial Management and Main Decisions of Financial Management. Difference between Risk , Speculation and Gambling.Time Value of Money. Interest Rate and Discount Rate. Present Value and Future Value .Discrete case as well as continuous compounding case. Annuities and its kinds. Meaning of Return. Return as Internal Rate of Return (IRR). Numerical Methods like Newton Raphson Method to calculate IRR. Measurement of Returns under Uncertainty situations. Meaning of Risk. Difference between Risk and Uncertainty. Types of Risks. Measurement of Risk. Calculation of Security and Portfolio Risk and Return-Markowitz Model. Sharp's Single Index Model Systematic Risk and Unsystematic Risk. Taylor Series and Bond valuation. Calculation of Duration and Convexity of Bonds. Financial Derivatives – Future , Forward, Swaps and Options. Call and Put Options. Call and Put Parity Theorem. Pricing of contingent claims through Arbitrage and Arbitrage Theorem. (40 Marks) Application of Mathematics in Insurance Insurance Fundamentals. Insurance defined. Meaning of Loss. Chances of Loss , Peril , Hazard and Proximate cause in insurance. Costs and Benifits of insurance to the society and branches of insurance. Life Insurance and various types of general Insurance. Insurable Loss Exposures. Feature of a Loss that is Ideal for Insurance. Life Insurance Mathematics. Construction of Mortality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life. Determination of Claims for General Insurance. Using Poisson Distribution and Negative Binomial Distribution. The Polya Case. Determination of the amount of the claim in General Insurance. Compound Aggregate claim model and its properties and claims of Reinsurance. Calculation of a Compound Claim Density Function. F-Recursive and approximate formulae for F. (35 Marks)

PAPER – III (OPTIONAL)

6. Special Theory of Relativity

Review of Newtonian Mechanics. Inertial Frames. Speed of Light and Galilean Relativity. Michelson Morley Experiment. Loretz Fitzgerald Contraction Hypothesis. Relative character of space and time.Postulates of special theory of relativity. Lorentz Transformation equations and its Geometrical interpretation. Group properties of Lorentz transformations. (15 Marks) Relativistic Kinematics. Composition of Parallel Velocities. Length Contraction. Time Dilation. Transformation equations for components of velocity and accelaration of a particle and Lorentz Contraction Factor. (15 Marks) Geometrical Representation of Space time. Four Dimensional Minkowskian Space Time of Special Relativity. Time -Like, Light Like and Space Like Intervals. Null Cone. Proper Time. World Line of a particle. Four Vectors and Tensors in Minkowskian Space Time. (15 Marks) Relativistic Mechanics. Variation of Mass with velocity. Equivalence of Mass and Energy. Transformation Equations for Mass Momentum and Energy. Energy-Momentum Four Vector. Relativistic Force and Transformation Equations for its Components. Relativistic Lagrangian and Hemiltonian. Relativistic Equations of motion of a particle. Energy Momentum Tensor of a Continuous Material Distribution. (15 Marks) Electromagnetism. Maxwell's Equations in Vacuo. Transformation Equations for the densities of electric charge and current. Propagation of electric and magnetic field strengths. Transformation equations for Electromagnetic four potential vector. Gauge Transformation Equations for electric and magnetic field strengths. Gauge Transformation. Lorentz invariance of Maxwell's Equations. Maxwell's equations in Tensor Form. Lorentz Force on a charged particle. Energy Momentum Tensor of an Electromagnetic Field. (15 Marks)

M.Sc. (Previous)
Mathematics

Paper I – ADVANCED ALGEBRA

Groups - Normal and Subnormal series, Composition Series, Jordan-Holder Theorem , Solvable Groups , Nilpotent groups.

Ring theory - Ring homomorphism , Ideals and Quotient Rings, Field of Quotients of an integral Domain , Euclidean Rings, Polynomial Rings, Polynomials over the Rational Field, The Eisenstien Criterion, Polynomial Rings over Commutative Rings, Unique fac torization domain. R Unique factorization domain implies so i & R [x1, x2 , x3 ,. . . .,xn]. Definition and examples of Vector Spaces, Subspaces, Sum and Direct Sum of Subspaces , Linear Span , Linear dependence, independence and their basic properties, Basis , Finite Dimensional Vector Spaces, Existence Theorem for Bases, Invariance of the number of elements of a basis set, Dimension , Existence of complementary subspace of a finite dimensional vector space, Dimension of sum of subspaces, Quotient space and its dimen sion, Linear transformations and their representation as matrices, The Algebra of Linear transformations. The rank Nulility Theorem, Change of Basis, Dual Space, Bidual Space and Natural isomorphism , Adjoint of a linear transformation, Eigen values and Eigen vectors of a Linear transformation , Diagonalisation , Annihilator of a Subspace, Bilinear, Quadratic and Hermitian Forms.

Inner Product Spaces -Cauchy - Schwarz Inequality , Orthogonal Vectors, Orthogonal Complements, Orthonormal Sets and Bases, Bessels' Inequality for finite dimensional spaces , Gram - Schmidt Orthogonalization process.

Canonical Forms- Similarlity of Linear Transformations, Invariant Subspaces, Reduction to Triangular Forms, Nilpotent Transformations, Index of Nilpotency, Invariants of a Nilpotent transformation,The primary decomposition Theorem,Jordan Blocks and Jordan Forms. Modules , Submodules, Quotient Modules, Homomorphism and Isomorphisms theorem. Cyclic Modules, Simple Modules, Semi-Simple Modules, Schuler's Lemma, Free Modules, Field Theory - Extension Fields , Algebraic and transcendental extensions, Separable and Inseparable Extensions, Normal Extensions, Perfect Fields, Finite Fields, Primitive Elements, Algebraically Closed Fields, Automorphisms of Extensions, Galois Extensions, Fundamental Theorem of Galois Theory, Solution of Polynomial Equations by Radicals, Insolvability of the General Equation of degree 5 by radicals.

Paper II – ANALYSIS (Real & Complex)

Section A : Real Analysis

Definition and Existence of Reimann-Stielijes Integral ,Properties of the integral,Integration and diffferentiation , the Fundamental Theorm of Calculus ,Rearrangements of terms of a series , Reimann's Theorem ,Sequences and Series of Functions , Pointwise and Uniform Convergence, Cauchy Criteria for Uniform Convergence , Weierstrass M-test , Abel's and Dirichlet's tests for uniform convergence , uniform convergence and continuity , uniform convergence and Reimann-Stielijes integration, uniform convergence and differentiation Weierstrass Approximation Theorem, Power series uniqueness theorem for power series. Abel's and Tauber's theorems. Functions of several variables , Linear Transformations , Derivatives in an Open subset of Chain Rule , Partial Derivatives , Interchange of the order of differentiation , Derivatives of high orders ,Taylor's Theorem ,Inverse function Theorem , Implicit Function Theorem , Jacobians , Lagrange's Multiplier Method. Lebesgue Outer Measure, Measurable Sets , Regularity , Measurable Functions, Borel

and Lebesgue Measurability , Non-measurable sets , Reimann and Lebesgue Integrals. Measures and Outer Measures , Extension of a Measure , Uniqueness of Extension Com pletion of a Measure , Measure Spaces , Integration with respect to a measure.

Section B: Complex Analysis

Complex Integration , Cauchy - Goursat Theorem ,Cauchy's Integral Formula ,Higher Order Derivatives , Morera's Theorem , Cauchy's Inequality and Liouville's Theorem , The Fundamental Theorem of Algebra , Taylor's Theorem , Maximum Modulus Principle , Schwarz Lemma , Laurent's Series , Isolated Singularities , Meromorphic Functions, The Argument Principle , Rouche's Theorem , Inverse Function Theorem.,Residues, Chauchy's Residue theorem, Evaluation of Integrals,Branches of Many Valued Functions with special refernce to arg z , log z and za , Bilinear Transformations, their properties and classifications, Definitions and examples of Conformal Mappings. Weierstrass' Factorization Theorem , Gamma Function and its properties, Reimann Zeta Function, Reimann's Functional Equation, Runge's Theorem, Mittag - Leffler's Theorem , Analytic Continuation,Uniqueness of Direct Analytic Continuation,Uniqueness of analytic continuation along a curve, Power series method of analytic continuation , Schwarz Reflection Principle. Canonical Products , Jensen's Formula , Poisson-Jensen Formula , Hadamard's Three Circles Theorem,Order of an Entire Function,Exponent of Convergence,Borel's theorem. Hadamard's Factorization Theorem.

Paper III – DIFFERENTIAL EQUATIONS

Preliminaries -Initial Value Problem and the Equivalent Integral Equation , m^{th} order equation in d -dimensions as a first order system , Concepts of local existence, Existence in the large and Uniqueness of solutions with examples.

Basic Theorems -Ascoli -Arzela Theorem , A theorem on Convergence of solutions of a family of initial value problems. Picard -Lindelof Theorem -Peano's existence theorem and corollary, Maximal Intervals of existence , Extension theorem and coroillaries,Kamke's Convergence Theorem , Kneser's Theorem (statement only).

Differential Inequalities and Uniqueness - Gronwall's Inequality , Maximal and Minimal solutions, Differential inequalities, A theorem of Winter , Uniqueness theoremsn Nagumo's and Osgood's criteria. Egres Points and Lyapunov Functions, Successive approximations.

Linear Differential Equations- Linear system, Variation of constants , reduction to smaller systems, Basic inequalities , constant coefficients , Floquet theory , Adjoint systems ,Higher order equations. Dependence on initial conditions and parameters;Preliminaries,Continuity, Differentiability , Higher order Differentiability. Poincare - Bendixson Theory -Autonomous systems, Umlanfsatz. Index of a stationary point. Poincare - Bendixson Theorem , Stability of Periodic solutions , Rotation points , Foci , Nodes and Saddle points.

Linear Second order Equations - Preliminaries, Basic facts, Theorems of Sturm , Sturm - Liouville Boundary Value Problems, Number of zeros, Nonoscillatory Equations and Principal solutions, Nonoscillation Theorems. Use of Implicit Function and Fixed Point Theorems- Periodic solutions,Linear Equations,

Nonlinear problems.

Second Order Boundary Value Problems - Linear problems,Nonlinear problems, Aprori bounds.

Paper IV – ADVANCE FLUID DYNAMICS

Kinematics of Fluids -Lagrange's and Euler's Methods, Stream Lines,Equation of Continuity , Boundary Surface , Equation of Motions of Non-Viscous Fluids - Euler's Equation of Motion (Vector form) , Bernoulli's Pressure Equation , Equation for Impulsive Motion (Vector form), Motion in

Two Dimensions : Stream Function , Complex Potential of the motion, Sources and Sinks in Two dimensions , Doublets , Images, Circle Theorem , Blasius
Theorem and its application.
General Theory of Irrotational Motion - Flow and Circulation, Permanence of Irrotational Motion, Kelvin's Circulation Theorem , Minimum Energy Theorem, Kulta Joukowski Theorem , Kinetic Energy of Infinite liquid , Motion of Cylinders , Motion of a Circular Cylinder , Liquid Streaming past a fixed circular cylinder , Motion of two co axial cylinders , Circulation about a Circular Cylinder , Motion of an Elliptic Cylinder ,Liquid streaming past a fixed Elliptic Cylinder , Rotating Elliptic Cylinders. Irrotational Motion in Three Dimensions: Motion of a sphere, Sphere through a liquid at rest at infinity , Liquid streaming past a fixed sphere, Equation of motion of a sphere.
Stokes Stream Function.
Vortex motion and its elementary properties, Kelvin's proof of permanence, Motions due to Circular and Rectilinear vortices, Wave motion in a gas, Speed of Sound , Equation of motion of a gas , Subsonic , Sonic and Supersonic flows of a gas, Isentropic gas flows , Flow through a Nozzle, Normal and oblique shocks. Stress components in a real fluid , Relations between rectangular components of stress, Connection between stresses and gradients of velocity ,Navier-Stoke's equations of motion,Plane Poiseuille and Couctte flows between two parallel plates,Theory of Lubrication , Flow through tubes of uniform cross section in form of circle, annulus , ellipse and equilateral triangle under constant pressure gradient, Unsteady flow over a flat plate. Dynamical Similarity , Buckingham p-Theorem, Reynolds Number , Prandfs boundary layer , Boundary Layer Equations in two-dimensions , Blasius Solution , Boundary Layer Thickness, Displacement Thickness , Karman Integral Conditions , Separation of boundary layer flow.
Paper V – ADVANCED DISCRETE MATHMATICS
Formal Logic-Statements, Symbolic Representation and Tautologies,Quantifiers,Predicates and Validity. Propositional Logic.
Semigroups & Monoids - Definitions and Examples of Semigroups and Monoids (including those pertaining to concatenation operation), Homomophism of Semigroups and Monoids , Congruence relation and Quotient Semigroups , Subsemigroup and Submonoids , Direct Products , Basic Homomorphism Theorem.
Lattices - Lattices as Partially Ordered Sets , Their properties , Lattices as Algebraic Systems , Sublattices , Direct Products and Homomorphisms , Some Special Lattices e.g. Complete , Complemented and Distributive Lattices. Boolean Algebras - Boolean Algebras as lattices , Various Boolean Idendtities , The Switching Algebra Example, Sub Algebras , Direct Products and Homomorphisms, Joinirreducible Elemets , Atoms and Minterms , Boolean Forms and their Equivalence, Minterm Boolean Forms , Sum of Products , Canonical Forms , Minimization of Boolean Functions, Applications of Boolean Algebra to Switching Theory (using AND , OR & NOT gates). The Karnaugh Map method.
Graph Theory- Definition of (undirected) Graphs Paths , Circuits; Cycles, & Subgraphs, Induced Subgraphs , Degree of vertex , Connecitvity , Planar Graphs and their properties , Trees , Euler's Formula for Connected Planar Graphs, Complete & Complete Bipartite Graphs , Kuratowski's Theorem (statement only) and its use, Spanning Trees , Cut -Sets ,
Fundamental Cut - Sets and Cycles, Minimal Spanning Trees and Kruskal's Algorithm , Matrix Representations of Graphs. Euler's Theorem on the Existence of Eulerian Paths and Circuits , Directed Graphs , In degree and Out degree of a vertex , Weighted unidrected Graphs , Dijkstra's Algorithm , Strong Connectivity & Warshall's Algorithm , Directed Trees , Search Trees , Tree Traversals.

Introductory Computability Theory : Finite State Machines and their Transition Table Diagrams, Equivalence of Finite State Machines , Reduced Machines , Homomorphism , Finite Automata , Acceptors , Non-deterministic Finite Automata and equivalence of its power to that of Deterministic Finite Automata , More and Mealy Machines. Turing Machine and Partial Recursive Functions.

Grammars and Languages -Phrase - Structure Grammars,Rewritting Rules,Derivations, Sentential Forms,Language generated by a Grammar ,Regular,Context -Free and Context Sensitive Grammars and Languages, Regular sets , Regular Expressions and the Pumping Lemma , Kleene's Theorem. Notions of Syntax Analysis, Polish Notations , Conversion of Infix Expressions to Polish Notations, The Reverse Polish Notation.

M.A./M.Sc. (Final)
Mathematics

Paper -I

PARTIAL DIFFERENTIAL EQUATIONS
AND THEIR NUMERICAL SOLUTIONS

Examples of PDE, Classification

Transport Equation - Initial Value Problem, Non-homogeneous Equation. Laplace's Equation - Fundamental Solution, Mean Value Formulae, Properties of Harmonic functions, Green's Function , Energy Methods.

Heat Equation - Fundamental Solution, Mean Value Formula,Properties of Solutions, Energy Methods.

Wave Equation - Solution by Spherical Means, Non-homogeneous Equations, Energy Methods. Nonlinear First Order PDE - Complete Integrals, Envelopes, Characteristics, Hamilton Jocobi Equations (Calculus of Variations , Hamilton's ODE , Legendre Transform, Hopf Lax Formula , Weak Solutions , Uniqueness) , Conservation Laws (Shocks , Entropy conditions , Lax-Oleinik Formula , Weak Solutions , Uniqueness , Riemann's Problem , Long Time Behaviour). Representation of Solutions - Separation of variables, Similarity Solutions (Plane and Travelling Waves,Solutions,Similarity under Scaling),Fourier and Laplace Transform,Hopf-Cole Transform , Hodograph and Legendre Transforms , Potential Functions , Asymptotics (Singular Perturbations, Laplace's Method , Geomatric Optics, Stationary Phase, Homogenization) , Power Series (Non Characteristics Surfaces, Real Analytic functions, Cauchy-Kovalevskaya Theorem). Deriving Difference Equations, Eltiptic equations : Solution of Laplace's equation ,Liebmann's Iterative method,Relaxation method ,Solution of Poisson's equations, Parabolic equations, Solution of heat equation,Bender -Schmidt method,The Crank-Nicholson method, Hyperbolic equations, Solution of hyperbolic equations.

Paper II

OPERATIONS RESEARCH

Operations Research and its Scope, Necessity of Operations Research in industry.

Linear Programming - Simplex and Revised Simplex Method , Theory of the Simplex method , Duality and Sensitivity Analysis, Other Algorithms for Linear Programming , Dual Simplex method Parametric Linear Programming , Upper Bound Technique , Interior Point Algorithm , Linear Goal Programming. Transportation and Assignment Problems.

Network Analysis- Shortest Path Problem, Minimum Spanning Tree Problem,Maximum Flow Problem,Minimum Cost Flow Problem,Network Simplex Method,Project Planning and Control with PERT-CPM.

Dynamic Programming- Deterministic and Probabilistic Dynamic programming. Game Theory-Two-Person , Zero-Sum Games, Games with Mixed Strategies, Graphical Solution, Solution by Linear Programming.

Integer Programming-Branch and Bound Technique Applications to industrial Problems - Optimal Product Mix and Activity Levels,Petroleum Refnery Operations, Blending Problems, Economic Interpretation of Dual Linear Programming problems, Input -Output Analysis, Leontief System, Indecomposable and Decomposable Economies.

Nonlinear Programming- One and Multi-Variable Unconstrained Optimization, Kuhn Tucker Conditions for Constrained Optimization,Quadratic Programming,Separable Programming,Convex Programming, Non-Convex Programming.

Paper III

TOPOLOGY

Countable and Uncountable Sets, Infinite sets and the Axiom of Choice , Cardinal Numbers and its Arithmetic, Schroeder-Bernstein Theorem, Cantor's Theorem and The Continum Hypothesis, Zorn's Lemma, Well -Ordering Theorem. Definition and Examples of Topological Spaces,Closed Sets,Closure,Dense Subsets ,Neighbour hoods, Interior,Exterior and Boundary,Accumulation Points and Derived sets,Bases and Sub-Bases, Subspaces and Relative Topology. Alternate methods of defining a Topology in terms of Kuratowski Closure Operator and Neighbourhood System. Continuous Functions and Homeomorphism. First and Second Countable Spaces, Lindelof's Theorems, Separable Spaces ,Second Countability and Separability. Separation Axioms T0 , T1, T2, T3, T4 their characterizations and basic properties. Urysohn's Lemma. Tietze Extension Theorem. Compactness, Continuous Functions and Compact sets, Basic properties of Compactness, Com pactness and Finite Intersection Property, Sequentially and Countably Compact Sets, Local Compactness and one point Compactification, Stonevech Compactification, Compactness in Metric Spaces, Equivalence of Compactness ,Countable Compactness and Sequential Compactness inMetric Spaces. Connected spaces, Connectedness on the Real line,Components,Locally Connected Spaces.Tychonoff Product Topology in terms of Standard Sub-base and Characterizations,Projection Maps, Separation Axioms and Product Spaces Connectedness and Product spaces.Compactness and Product Spaces (Tychonoff Theorem). Countability and Product Spaces, Embedding and Metrization, Embedding Lemma and Tychonoff Embedding , The Urysohn Metrization Theorem. Nets and Filters, Topology and Convergence of Nets, Hausdorffness and Nets, Compactness andNets, Filters and their Convergence, Cononical way of converting Nets to Filters and vice-versa , Ultra - Filters and Compactness. Metrization Theorems and Paracompactness -Local Fintieness, The Nagata-Smirnov Metrization Theorem, Paracompactness, The Smirnov Metrization Theorem. The Fundamental Group and Covering Spaces - Homotopy of Paths,The Fundamental Group,Covering Spaces,The Fundamental Group of the Circle and Fundamental Theorem of Algebra.

OPTIONAL PAPERS (Any Two of the following)

1. FUNCTIONAL ANALYSIS
2. MATHEMATICAL STATISTICS.
3. PROGRAMMING IN C:THEORY & PRACTICAL(Only for Regular Student)
4. DIFFERENCE EQUATIONS.
5. INTEGRAL EQUATIONS & BOUNDARY VALUE PROBLEMS.
6. SOLAR MAGNETO HYDRODYNAMICS.
7. INFORMATION THEORY.
8. FUZZY SETS AND THEIR APPLICATIONS.
9. DIFFERENTIAL GEOMETRY OF MANIFOLDS.
10. WAVELETS.
11. BIOMECHANICS.
12. PLASMA DYNAMICS.
13. GENERAL RELATIVITY & COSMOLOGY.
14. Dissertation may be opted as one of the optional paper only for regular students who have obtained at least 60% Marks in M.Sc. Previous.

(Detailed Course of Some Optional Papers)

1. FUNCTIONAL ANALYSIS

Normed Linear Spaces, Banach Spaces and examples, Quotient Space of Normed Linear Spaces and its Completeness, Equivalent Norms, Riesz Lemma, Basic properties of Finite Dimensional

Normed Linear Spaces and Compactness,Weak Convergence and Bounded Linear Transformations, Normed Linear Spaces of Bounded Linear Transformations, Dual Spaces with examples, Uniform Boundedness Theorem and some of its consequences, Open mapping and Closed graph theorems, Hahn - Banach Theorem for Real Linear Spaces, Complex Linear Spaces and Normed Linear Spaces, Reflexive Spaces,Weak Sequential Compactness, Compact Operators, Solvability of Linear Equations in Banach Spaces, The Closed Range Theorem. Inner Product Spaces, Hilbert Spaces, Orthonormal Sets, Bessel's Inequality, Complete Orthonormal Sets and Parseval's Identity, Structure of Hilbert Spaces, Projection Theorem, Riesz Representation Theorem , Adjoint of an operator on a Hilbert Space, Reflexivity of Hilbert Spaces , Self-adjoint Operators, Positive Projection , Normal and Unitary Operators, Abstract Variational Boundary Value Problem, The generalized Lax-Milgram Theorem.

2. MATHEMATICAL STATISTICS

Probability - Set Theoretic Approach, Boole's Inequality , Baye's Theorem , Geometric Probability. Random Variables - Distribution Function , Joint Probability Distribution Function, Conditional Distribution Function , Transformation of one and two dimensional Random Variables. Mathematical Expectation , Covariance, Variances of n Variates, Chebycheffs Inequality , Weak and Strong Laws of Large numbers.Moment Generating and Characteristic Functions and Cumulants- Study of the following Distributions, their relationship with each other, distribution of their sum, difference, product , quotient etc. (a) Binomial , Poisson , Negative Binomial , Geometric, Pascal's , Polya's Hypergeometric Distributions, Multinomial Power Series and Discrete Uniform, Compound Binomial and Poisson Distributions. (b) Normal , log-normal ,Gamma , Beta , Exponential , Bivariate Normal , Laplace , Weibul , Cauchy and Pearson's Distributions. Central Limit Theorem, Underberrg-Levy Theorem, Derivation of Chi-Square Distributions , Non Central Chi-Square Distribution , Test of Significance. Distribution Function-of t , F and z Test of Significance. Theory of Estimates-Principle of Maximum Likelihood ,Properties of Maximm Like lihood Estimators, Analysis of Variance-Analysis of Variance in one way and two way classification.

3. DIFFERENCE EQUATIONS

Introduction, Difference Calculus -The Difference Operator , Summation , Generating Functions , Approximate Summation. Linear Difference Equations -First Order Equations,General Results for Linear Equation,Equations with Constant Coefficients, Applications, Equations with Variable Coefficients,Nonlinear Equations that can be linearized , The z- Transform. Stability Theory- Initial Value Problems for Linear Systems, Stability of Linear Systems, Stability of Nonlinear Systems, Chaotic Behaviour. Asymptotic Methods - Introduction, Asymptotic Analysis of sums, Linear Equations,Nonlinear equations. The Self-Adjoint Second Order Linear Equation - Introduction,Sturmain Theory,Greens Functions, Disconjugacy, The Riccati Equations, Oscillation. The Sturm-Liouville Problem-Introduction,Finite Fourier Analysis ,A Nonhomogeneous problem.

Discrete Calculus of Variations - Introduction, Necessary Conditions, Sufficient Conditions and Disconjugacy. Boundary Value Problems for Nonlinear Equations- Introduction,The Lipschitz Case. Existence of Solutions, Boundary Value Problems for Differential Equations. Parital Differential Equations. Discretization of Parital Differential Eqations. Solution of Partial Differential Equations.

4. INTEGRAL EQUATIONS AND BOUNDARY VALUE PROBLEMS

Definitions of Integral Equations and their classification, Eigen values and Eigen functions, Fredholm integral equations of second kind with separable kernels,Reduction to a system of alge braic equations, An Approximate Method , Method of Successive Approximations, Iterative Scheme for Fredholm integral equations of the second kind,Conditions of uniform convergence and Uniqueness of Series solution, Resolvent kernel and its results, Application of iterative Scheme to

Volterra integral equations of the second kind. Classical Fredoholm Theory, Fredholm Theorems. Integral Transform Methods,Fourier Transform,Laplace Transform , Convolution integral,Application to Volterra integral equations with convolution type kernels,Abel's equations,Inversion formula for singular integral equations with kernel of the type $h(s) – h(t) – a$, $0 < a < 1$, Cauchy's Principal Value of singular integrals, Solution of Cauchy-type singular integral equation,The Hilbert kernel, Solution of the Hilbert-Type singular integral equation. Symmetric kernels,Complex Hilbert Space, Orthonormal system of functions,Fundamental prop erties of eigen values and eigen functions for symmetric kernels, Expansion in eigen function and bilinear form, Hilbert Schmidt Theorem and some immediate consequences, Solutions of integral equations with symmtric kernels. Definition of a boundary value problem for an ordinary differential equation of the second order and its reduction to a Fredholm integral equation of the second kind, Dirac Delta Function, Green's function approach to reduce boundary value problems of a self-adjoint differential equation with homogeneous boundary conditions to integral equation forms.Auxiliary problem satisfied by Green's function, Integral equation formulations of boundary value problems with more general and inhomogeneous boundary conditions, Modified Greens' function. Integral representation formulas for the solution of the Laplace's and Poisson's equations, Newtonian single-layer and double layer potentials, Interior and exterior Dirichlet and Neumann boundary value problems of Laplace's equation , Green's function for Laplace's equation in a free space as well as in a space bounded by a ground vessel, Integral equation formulation of boundary value problems for Laplace's equation. Poisson's integral formula , Green's function for the space bounded by grounded two parallel plates or an infinite circular-cylinder. Perturbation techniques and its applications to mixed boundary value problems, Two part and three-part boundary value problems. Solutions of electrostatic problems involving a charged circular disk and annular circular disk, a spherical cap, an annular spherical cap in a free space or a bounded space. (For Detailed Course of other Optional Papers Consult University Syllabus)

DISSERTATION

Dissertation may be opted as one of the optional paper only for regular students who have obtained at least 60% Marks in M.Sc. Previous.

Note: The Dissertation shall be evaluated by the Supervisor and an External Examiner appointed by the University. Both examiners shall have equal weightage to award the marks.