RECOMMENDED SYLLABUS OF

MATHEMATICS

M.A./M.Sc. (Previous)

(From the Session 2018-19 onwards)

Paper I – REAL ANALYSIS M.M. : 90

Dedekind's theory of real numbers, Construction of the real field from the field of rational numbers.

Definition and existence of Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Fundamental theorem of integral calculus, Uniform convergence and Riemann-Stieltjes integration, Integration of vector-valued functions, Rectifiable curves, Weierstrass approximation theorem, Power Series, Uniqueness theorem for power series, Abel's and Tauber's theorems.

Functions of several variables : Eucledian spaces, Concept of functions of several variables, Linear transformations, Continuous functions, Derivatives in an open subset of R^n, Chain rule, Partial derivatives, Interchange of the order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem, Implicit function theorem.

Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability.

Integration of non-negative functions, The general integral, Integration of series, Riemann and Lebesgue integrals.

Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and integration.

Measures and outer measures, Extension of a measure, Uniqueness of extension, Completion of measure, Measure spaces, Integration with respect to a measure.

The L^p-spaces, Convex functions, Jensen's inequality, Holder and Minkowski inequalities, Completeness of L^p, Convergence in measure, Almost uniform convergence.

References :

1. *Walter-Rudin* : Principles of Mathematical Analysis (3rd edition) McGraw-Hill Kogakusha, 1976, International Student edition.
2. *T.M. Apostol* : Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
3. *I.P. Natanson* : Theory of Functions of a Real Variable,Vol. I, Frederick Ungar Publishing Co., 1961.

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4. *H L. Royden* : Real Analysis, Macmillan Pub. Co. Inc., 4th Edition, New York, 1993.
5. *Parijat Sinha* : Real Analysis, Kedar Nath Ram Nath Publications, Meerut.

Paper II – COMPLEX ANALYSIS M.M. : 90

Cauchy-Goursat theorem, Poisson integral formula, Cauchy's integral formula for derivatives, Concepts of derivatives and integrals of fractional orders, Cauchy's inequality, Liouville's theorem, Morera's theorem, Taylor's and Laurent's theorems, Maximum modulus principle, Schwarz lemma, Meromorphic functions, Inverse function theorem.

Residues, Cauchy's residue theorem, Evaluation of integrals, Branches of many-valued functions with special reference of arg z, log z and z^a.

Weierstrass' factorization theorem, Gamma function and its properties, Riemann zeta function, Riemann functional equation, Mittag-Leffler's theorem, Riemann mapping theorem.

Analytic continuation, Uniqueness of analytic continuation along a curve, Power Series method of analytic continuation, Natural boundary, Schwarz reflection principle, Harmonic functions on a disc, Harnack's inequality and theorem, The Dirichlet problem, Green's function.

Canonical products, Jensen's formula, Hadamard's three circles theorem, Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization theorem.

Univalent functions, Bieberbach's theorem (statement only) and the 1/4 theorem, Definitions, examples and simple properties of starlike and convex functions.

References :

1. *H.A. Priestly* : Introduction to Complex Analysis, Clarendon Press, Oxford 1990.
2. *L.V. Ahlfors* : Complex Analysis, McGraw-Hill, 1979.
3. *S.Lang* : Complex Analysis, Addison Wesley, 1977.
4. *Walter Rudin* : Real and Complex Analysis, McGraw-Hill Book Co., 1966.
5. *E.C. Tithmarsh* : The theory of Functions, Oxford University Press, London.
6. *S. Ponnusamy* : Foundations of Complex Analysis, Narosa Publishing House.
7. *A.W. Goodman* : Univalent Functions, Vol. I & II, Mariner Publishing Co.

Paper III – TOPOLOGY M.M. : 90

Completeness of metric spaces, Cantor's Intersection theorem, Dense sets, Baire category theorem, Separable spaces, Continuous functions, Extension theorem, Uniform continuity, Isometry and homeomorphism, Equivalent metrics, Compactness, Sequential

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compactness, Totally bounded spaces, Finite intersection property, Continuous functions and compact sets.

Axiom of choice, Zermelo's postulate, Zorn's lemma, Well-ordering theorem, Cardinal number and its arithmetic, Schroeder-Bernstein theorem, Cantor's theorem and the continuum hypothesis.

Definition and examples of topological spaces, Neighbourhoods, Closed sets, Limit points and derived sets, Closure, interior, exterior and boundary of a set, Dense and nowhere dense sets, Bases and sub-bases, Subspaces and relative topology, Metric topologies and equivalent metrics.

Characterization of topology in terms of Kuratowski closure operator and fundamental system of neighbourhoods.

Continuous maps and homomorphism.

First and second countable spaces, Lindelof's theorem, Separable spaces, Second countability and separability.

Separation axioms, T_0, T_1, T_2, T_3 and T_4 spaces, their characterizations and basic properties, Urysohn's lemma, Tietze extension theorem.

Compactness, Continuous functions and compact sets, Basic properties of compactness, Finite intersection property, Sequentially and countably compact sets.

Connected spaces, Connectedness on the real line, Components, Locally connected spaces.

Tychonoff product topology in terms of standard sub-base and its characterizations, Projection maps, Separation axioms and product spaces, Connectedness and product spaces, Compactness and product spaces (Tychonoff's 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 and nets, Filters and their convergence.

References :

1. *K.D. Joshi* : Introduction to General Topology, Wiley Eastern Ltd., 1983.
2. *J.L. Kelley* : General Topology, Van Nostrand, Reinhold Co., New York, 1995.
3. *J.R. Munkers* : Topology, Pearson, 2015.
4. *G.F. Simmons* : Introduction to Topology and Modern Analysis, McGraw Hill Book Co., 1963.
5. *M.J. Mansfield* : Introduction to Topology, D. Van Nostrand Co. Inc. Princeton, N.J., 1963.

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Paper IV – RIGID DYNAMICS & CALCULUS OF VARIATIONS

M.M. : 90

Rigid Dynamics (75 %)

Moments and products of inertia, Momental ellipsoid, Equimomental systems, Principal axes.

D'Alembert's principle, 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, Compound pendulum, Centre of percussion.

Motion of a rigid body in two dimensions under finite and impulsive forces.

Conservation of momentum and energy, Initial motions, Lagrange's equation (D'Alembert's and Hamilton's approaches), Euler's equations of motion, Hamilton's principle, Hamilton's equation of motion.

Calculus of Variations (25 %)

Variational problems with fixed boundaries - Euler's equation for functionals containing first order derivative and one independent variable, Externals, 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 co-ordinates transformation.

Variational problems with moving boundaries. Functionals dependent on one and two functions, One sided variations.

Sufficient conditions for an extremum. Jacobian and Legendre conditions, Second variation, Variational principle of least action.

References :

1. *S.L. Loney* : An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 1956.
2. *Synge, John L. & Griffith Byron, A.* : Principles of Mechanics, McGraw Hill Book Co., 1949.
3. *A.S. Gupta* : Calculus of Variations with Applications, Prentice Hall of India, 1997.
4. *I.M. Gilgand and S.V. Fomin* : Calculus of Variations, Prentice Hall, Englewood Cliffs (New Jersey), 1963.
5. *M.A. Pathan, V.B.L. Chaurasia, P.K. Banerji & M.C. Goyal* : Special Functions and Calculus of Variations, Indus Valley Publications, New Delhi, 2004 (Hard Cover), and Ramesh Book Depot, New Delhi and Jaipur.

Paper V – OPTIONAL PAPER **M.M. : 90**

CHOOSE ANY ONE OF THE FOLLOWING PAPERS **:**

Paper V(*a*) – PROGRAMMING IN *C* (with ANSI features)

An overview of programming, Programming language, Classification.

***C* Essentials** - Program Development, Functions, Anatomy of a *C* Function, Variables and constants, Expressions, Assignment statements, Formatting source files, Continuation character, The preprocessor.

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Scalar Data Types - Declarations, Different Types of Integers, Different kinds of integer constants, Floating-Point Types, Initialization, Mixing Types, Explicit Conversions-Casts, Enumeration Type, The Void Data Type, Type defs, Finding the Address of an object, Pointers.

Control Flow - Conditional Branching, The Switch Statement, Looping, Nested Loops, the break and continue Statements, The goto statement, Infinite Loops.

Operators and Expressions - Precedence and Associativity, Binary Plus and Minus operators, Binary Arithmetic Operators, Arithmetic Assignment Operators, Increment and Decrement Operators, Comma Operators, Relational Operators, Logical Operators, Bit-Manipulation Operators, Bitwise Assignment operators, Cast Operator, Size of Operators, Conditional Operators, Memory Operators.

Arrays and Pointers - Declaring and Array, Arrays and Memory, Initilizing Arrays, Encryption and Decryption, Pointer Arithmetic, Passing Pointers as function Arguments, Accessing Array Element through Pointers, Passing Arrays as Function Arguments, Sorting Algorithms, Strings, Multidimensional Arrays, Arrays of Pointers, Pointers, Pointers to Pointers.

Storage Classes - Fixed vs Automatic Duration, Scope, Global Variables, The register specifier, ANSI rules for the syntax and Semantics of the storage-class keywords, Dynamic Memory Allocation.

Structure and Unions - Structures, Linked Lists, Unions, Enum Declarations.

Functions - Passing Arguments, Declarations and Calls, Pointers to Functions, Recursion, The main ( ) Function, Complex Declarations.

The *C* Preprocessor - Macro Substitution, Conditional Complication, Include Facility, Line Control.

Input and Output - Streams, Buffering, The <Stdio.h> Header File, Error Handling, Opening and Closing a File, Reading and Writing Data, Selecting an I/O Method, Unbuffered I/O Random Access, The standard library for Input/Output.

References :

1. *Peter A. Darnell and Philip E. Margolis, C* : A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 1993.
2. *Brian W. Kernighan and Dennis M. Ritchie* : The *C* Programme Language, 2nd Edition (ANSI features), Prentice Hall 1989.

Paper V(*b*) – 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 in the large and uniqueness of solutions with examples.

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Basic Theorems - Ascoli-Arzela Theorem, A theorem on convergence of solutions of a family of initial value problems.

Erges point and Lyapunov functions, Successive approximations.

Linear Differential Equations - Linear Systems, Variation of constants, Reduction to smaller systems, Basic inequalities, Constant cofficients, Floquest theory, Adjoint systems, High order equations.

Dependence on initial conditions and parameters : Preliminaries, Continuity, Differentiability, Higher Order Differentiability.

Poincare-Bendixson theory - Autonomous systems, Unlanfsatz, Index of a Stationary point.

Poincare - Bendixson theorem, Stability of periodic solutions, rotation points, foci, nodes and saddle point.

Linear second order equations - Preliminaries, Basic facts, Theorems of Strum, Strum-Liouville Boundary Value Problems, Number of zeros, Non-oscillatory equation and principal solutions, Non-oscillation theorems.

Use of Implicit function and fixed point theorems - Periodic solutions, Linear equations, Non-linear problems.

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

References :

1. *P. Hartman,* Ordinary Differential Equations, John Wiley (1964).
2. *E.A. Coddington and N. Levinson,* Theory of Ordinary Differential Equations, McGraw Hill, NY (1965).

Paper V(c) – ADVANCED DISCRETE MATHEMATICS

Formal Logic - Statements, Symbolic Representation and Tautologies, Quantifiers, Predicates and Validity, Propositional Logic.

Semigroups and Monoids - Definitions and Examples of Semigroups and Monoids (including those pertaining to concatenation operation), Homomorphism of semigroups and monoids, Congruence relation and Quotient Semigroup, Subsemigroup and sub-monoids, Direct products, Basic homomorphism theorem.

Lattices - Lattices as partial ordered sets, their properties, Lattices as Algebraic systems, Sub-lattices, Direct Products and Homomorphisms, Some Special Lattices e.g. Complete, Complemented and Distributive Lattices.

Boolean Algebras - Boolean Algebras as Lattices, Various Boolean Identities, The Switching Algebra example, Sub-algebras, Direct Products and Homomorphisms, Join-

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irreducible elements, Atoms and Minterns, Boolean forms and their equivalence, Minterm Boolean forms, Sum of Products, Canonical Forms, Minimization of the Boolean Functions, Applications of Boolean Algebra to switching theory (using AND, OR and NOT gates), the Karnaugh Map Method.

Graph Theory - Definition of (Undirected) Graphs, Paths, Circuits, Cycles and Subgraphs, Induced Subgraphs, Degree of a vertex, Connectivity, Planar Graphs and their properties, Trees, Euler's Formula for connected Planar Graphs, Complete and 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 Representation of Graphs, Euler's Theorem on the Existence of Eulerian Paths and Circuits, Directed Graphs, Indegree and Outdegree of vertex, Weighted undirected Graphs, Dijkstra's Algorithm, Strong Connectivity and 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, Moore and Mealy Machines, Turning Machine Partial Recursive Functions.

Reference :

1. *J.P. Tremblay and R. Manohar*, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co. 1997.
2. *Seymour Lepschutz*, Finite Mathematics (International edition, 1983), McGraw-Hill Book Company, New York.
3. *C.L. Liu*, Elements of Discrete Mathematics, Mc-Graw Hill Book Co.

Paper V(*d*) – DIFFERENTIAL GEOMETRY OF MANIFOLDS

Definition and examples of differentiable manifolds, Tangent spaces, Jacobian map, One parameter group of transformations, Lie derivatives, Immersions and imbeddings, Distributions, Exterior algebra, Exterior derivative.

Topological groups - Lie groups and Lie algebras, Product of two Lie groups, One parameter sub-groups and exponential maps, Examples of Lie groups, Homomorphism and Isomorphism, Lie transformation groups, General linear groups, Principal fibre bundle, Linear frame bundle, Associated fibre bundle, Vector bundle, Tangent bundle, Induced bundle, Bundle homomorphisms.

Riemannian Manifolds - Reimannian connection, Curvature tensors, Sectional Curvature, Schur's theorem, Geodesics in a Riemannian manifold, Projective curvature tensor, Conformal curvature tensor.

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Sub-manifolds and Hypersurfaces – Normals, Gauss' formulae, Weingarten equations, Lines of curvature, Generalized Gauss and Minardi-Codazzi equations.

Almost complex manifolds, Nijenhuis tensor, Contravariant and Covariant almost analytic vector fields, F-connection.

References :

1. *R.S. Mishra*, A course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd., 1965.
2. *R.S. Mishra*, Structures on Differentiable Manifolds and their Applications, Chandrama Prakashan, Allahabad, 1984.
3. *Brian C. Hall*, Lie Groups, Lie Algebras and Representations : An Elementary Introduction, Springer, 2004.
4. *K. Yano and M. Kon*, Structure of Manifolds, World Scientific Publishing Co. Pvt. Ltd., 1984.

Paper V(*e*) – MATHEMATICAL STATISTICS

Moments, Method of least squares and curve fitting, Moments of bivariate distribution, correlation coefficient and regression, Partial and multiple correlation for three variables.

Probability. Axiomatic definition of probability, Independent events, Baye's theorem, discrete and continuous random variables.

Distribution Functions. Probability mass function (pmf) and probability density function (pdf), Mathematical Expectation of random variables, Joint distribution function of two random variables, Conditional and marginal pdf and pmf, Conditional expectation, Chebyshev's and Markov's inequalities, Central Limit Theorem.

Moment Generating functions. Characteristic function, Cumulant generating function, MGF of Binomial, Poisson's and Normal distributions, Continuous distributions, Gamma distribution, Beta distribution of the first and second kinds, Rectangular distribution, Moments in terms of cumulants.

Continuous bivariate probability distributions. Bivariate normal distribution, Marginal and conditional bivariate distributions.

Sampling theory. Simple random sampling with and without replacement, Stratified random sampling, Neyman allocation, Proportional allocation, Ratio method of estimation.

Chi square distribution, t, F and z distributions, Distributions of functions of random variables (for two random variables only).

Analysis of the variance and design of experiments. One way and two way classifications, Principles of design, CRD, RBD and Latin square design.

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Estimation and testing. Definition of statistic, Unbiased estimator, Consistent, estimator, Sufficient estimator, Method of maximum likelyhood estimation, Minimum variance estimator, Sufficient statistic, Two types of error, Neyman-Pearson (NP) lemma, Problems based on NP lemma.

References :

1. *Mayer* : Introduction to Mathematical Statistics.
2. *Goon, Gupta and Dasgupta* : Fundamentals of Statistics (Vol. I, II, III), World Press.
3. *M. Ray and H.S. Sharma* : Mathematical Statistics, Ram Prasad and Sons, Agra.
4. *J.K. Goyal and J.N. Sharma* : Mathematical Statistics.

Paper V(*f*) – MECHANICS OF SOLIDS

Analysis of Strain - Affine transformations, Infinitesimal affine deformation, Geometrical interpretation of the components of strain, Strain quadric of Cauchy, Principal strains and invariants, General infinitesimal deformation, Saint-Venant's equations of Compatibility, Finite deformations.

Analysis of stress - Stress tensor, Equations of equilibrium, Transformation of co-ordinates, Stress quadric of Cauchy, Principal stress and invariants, Maximum normal and shear stresses.

Equations of Elasticity - Generalised Hooke's law, Homogeneous isotropic media, Elasticity moduli for isotropic media, Equilibrium and dynamic equations for an isotropic elastic solid, Strain energy function and its connection with Hooke's law, Uniqueness of solution, Beltrami-Michell compatibility equations, Saint-Venant's principle.

Torsion - Torsion of cylindrical bars, Tortional rigidity, Torsion and stress functions, Lines of shearing stress, Simple problems related to circle, ellipse and equilateral triangle.

Two-dimensional Problems - Plane stress, Generalized plane stress, Arry stress function, General solution of Biharmonic equation, Stresses and displacements in terms of complex potentials, Simple problems, Stress function appropriate to problems of plane stress, Problems of semi-infinite solids with displacements or stresses prescribed on the plane boundary.

Waves - Propagation of waves in an isotropic elastic solid medium, Waves of dilatation and distortion, Plane waves, Elastic surface waves such as Rayleigh and Lowe waves.

Variational methods - Theorems of minimum potential energy, Theorems of minimum complementary energy, Reciprocal theorem of Betti and Rayleigh, Deflection of

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elastic string, Central line of a beam and elastic membrane, Torsion of cylinders, Variational problem related to biharmonic equation, Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.

References :

1. *I.S. Sokolnikoff,* Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1977.
2. *A.E. Love,* A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, London, 1963.
3. *Y.C. Fung,* Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
4. *S. Timoshenko and N. Goodier*, Theory of Elasticity,McGraw Hill, New York, 1970.

Paper V(*g*) – OPERATIONS RESEARCH

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

Linear Programming - 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-refinery operations, Blending problems, Economic interpretation of dual linear programming problems, Input-output analysis, Leontief system, Indecomposable and Decomposable economics.

Non-linear Programming - One and Multi-variable Unconstrained Optimization, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Separable Programming, Convex Programming, Non-convex Programming.

Reference :

1. *F.S. Hiller and G.J. Lieberman,* Introduction to Operations Research (Sixth Edition), McGraw Hill Publishing Co. International Edition, Industrial Engineering Series, 1995.

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2. *G. Hadley,* Linear Programming, Narosa Publishing House, 1995.
3. *H.A. Taha,* An Introduction to Operations Research, Macmillan Publishing Co. Inc, New York.
4. *Kanti Swarup, P.K. Gupta and Man Mohan,* Operations Research, Sultan Chand and Sons, New Delhi.
5. *Prem kumar Gupta and D. S. Hira,* Operations Research - An Introduction, S. Chand and Co. Ltd., New Delhi.

Project Work & Viva Voce. **M.M. : 50**

Every student shall choose a topic *related to* the syllabus of Mathematics prescribed for M.A./M.Sc. (Previous) *in or around the first week of December* and shall prepare a Project comprising of, *neatly handwritten* or *typed*, 20 to 30 pages of A-4 size after consultation with the *subject teacher*. The first page of the Project shall consist of the name of the *College* and *Department*, *Academic Session*, *Title of the Project*, *Name of the Student* including his/her *Class* and *Roll No.* (if available). The project should be **signed by the student and checked by the teacher**. Out of 50 marks, 20 marks shall be for the Project and remaining 30 marks for viva on the Project as-well-as on the entire syllabus of Mathematics for M.A./M.Sc. (Previous). At the time of Viva Examination, the student shall present his/her Project on the black board or through Power Point.

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

(From the Session 2019-20 onwards)

Paper I – ADVANCED ABSTRACT ALGEBRA M.M. : 90

Groups. Normal and subnormal series, Composition series, Jordan-Holder theorem, Solvable groups, Nilpotent groups, p-Sylow subgroup, Cauchy's theorem, Conjugacy relation, Class equation, Direct product, Sylow's theorems, Structure theorem for finite abelian groups.

Integral domain, Imbedding theorem, Prime and maximal ideals, Quotient rings, Euclidean rings, Polynomial rings, Gaussian ring, Unique factorization theorem.

Cyclic modules. Modules, Submodules, Quotient module, Isomorphism theorem, Simple modules, Semi-simple modules, Schuler's Lemma, Free modules.

Noetherian and artinian modules and rings. Hilbert basis theorem, Wedderbuen-Artin theorem, Uniform modules, Primary modules, Noether-Lasker theorem.

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.

Canonical Forms. Similarity 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.

References :

1. *I.N. Herstain* : Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. *N. Jacobson* : Basic Algebra, Vols. I & II, W. H. Freeman, 1980 (also published by Hindustan Publishing Company).
3. *V.K. Khanna & S.K. Bhambri* : A Course in Abstract Algebra, Vikas Publishing House Pvt. Ltd., New Delhi.
4. *Vivek Sahai & Vikas Bist* : Algebra, Narosa Publishing House, New Delhi, 1999.

Paper II – FLUID DYNAMICS M.M. : 90

Kinematics. Lagrangian and Eulerian method, Equation of continuity, Boundary surface, Stream lines, Path lines and streak lines, Velocity potential, Vortex line, Rotational and irrotational motion.

Equation of motion. Euler's and Lagrange's equations of motion, Bernoulli's equations, Equation of impulsive action.

Motion in two dimensions, sources and sinks. Motion is two dimensions, Stream or current function, Irrotational motion in two dimensions, Complex potential, Sources, Sinks, Doublets

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and their images, The Milne-Thomson circle theorem, Theorem of Blasius, Flow and circulation, Kelvin's circulation theorem, Permanence of irrotational motion, Kinetic energy of infinite liquid.

Motion of cylinders. General equation of cylinder, Kinetic energy, Motion of circular, coaxial and elliptic cylinders, liquid streaming past a fixed circular and elliptic cylinders, Kinetic energy of elliptic cylinder.

Motion of a sphere. Motion of sphere through liquid at rest at infinity, Liquid streaming past a fixed sphere, Equation of motion of sphere, Stoke's stream function.

Vortex Motion. Vortex motion, Vortex filament, Complex potential, Image of vortex, Complex potential due to vortex doublet, Spiral vortex, Rankine combined vortex, Rectilinear vortex with elliptic cross-section, Routh's theorem, Motion of any vortex.

Gas Dynamics (Flow of inviscid compressible fluid). Basic equation of motion of a gas, Wave equation, Speed of sound in a gas, Mach number, Subsonic, sonic and supersonic flow in a gas, Isentropic gas flow, Flow through nozzle, Normal and oblique shock wave.

Stresses and rate of strain. Newton's law of viscosity, Newtonian and non-Newtonian fluids, Definitions of stress, strain and their relations, Relation between stresses and rate of strain, Navier-Stoke's equation, Dissipation of energy.

Laminar flow of viscous incompressible fluids. Plane and generalized Couette flow, Plane Poiseuille and Hagen-Poiseuille's flow, Steady flow through tubes of uniform cross-section in the form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient, Flow between two concentric rotating cylinders, Unsteady flow on a flat plate and between two parallel plates.

References :

1. *W.H. Basaint and A.S. Ramsey,* A Treatise on Hydromechanics, CBS Publishers, Delhi, 1988.
2. *R.K. Rathy,* An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
3. *A.D. Young,* Boundary Layers, AIAA Education Series, Washington DC, 1989.

Paper III – FUNCTIONAL ANALYSIS M.M. : 90

Normed linear spaces, Examples and its topological properties, Banach spaces, Continuous linear transformations, Spaces of continuous linear transformations from a linear space to a Banach space, Continuous linear functionals.

Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces, Natural imbedding of N in N^{**}, Open mapping theorem, Closed graph theorem, Conjugate of an operator, Banach-Steinhaus theorem, Uniform boundedness theorem and some of its consequences.

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Conjugate spaces, Weak and weak* topologies on a conjugate space, Simple applications to reflexive separable spaces and to the calculus of variation.

Hilbert spaces, Schwarz's inequality, Orthogonal complement of a subspace, Orthonormal sets, Bessel's inequality, Continuous linear functionals on Hilbert spaces, Riesz representation theorem, Reflexivity of Hilbert spaces, Adjoint of an operator on a Hilbert space, Self-adjoint operators, Normal and unitary operators on a Hilbert space, Projections on a Hilbert space.

Finite dimensional spectral theory : Determinant and the spectrum of an operator, The spectral theorem.

References :

1. *G.F. Simmons,*	Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, New York, 1963.
2. *G. Bachman and L. Narici,*	Functional Analysis, Academic Press, 1966.
3. *A.E. Taylor,*	Introduction to Functional Analysis, John Wiley and Sons, New York, 1958.
4. *S. Ponnusamy,*	Foundations of Functional Analysis, Narosa Publishing House, New Delhi, 2002.
5. *N. Saran & S.L. Shukla,*	Functional Analysis, Pragati Prakashan, Meerut.
6. *B.V. Limaye,*	Functional Analysis, Wiley Eastern.

Paper IV – INTEGRAL EQUATIONS AND BOUNDARY VALUE PROBLEMS M.M. : 90

Definition of integral equations and their classifications, Solution of integral equations.

Fredholm integral equations of the second kind with separable kernels, Reduction to a system of algebraic 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 result, Eigen values and Eigen functions, Classical Fredholm theory - Fredholm theorems.

Conversion of differential equations to integral equations : Initial value problems, Application of iterative scheme to Volterra integral equations of the second kind, Method of successive approximation for Volterra integral equations.

Integral transform methods : Fourier transform, Laplace transform, Convolution integral, Application to Volterra integral equations with convolution type kernels.

Symmetric kernels : Complex Hilbert space, Orthonormal system of functions, Fundamental properties of eigen values and eigen functions for symmetric kernels.

Hilbert Schmidt theorem and some immediate consequences, Solution of integral equations with symmetric 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 the Cauchy type

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singular integral equations, The Hilbert kernel, Solution of the Hilbert type singular integral equations.

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, 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, Dirac Delta function, Modified Green's function.

Integral representation formulae for the solution of the Laplace's and Poisson equations, Newtonian single layer and double layer potentials, Interior and exterior Dirichlet and Neumann boundary value problems for 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.

References :

1. *R.P. Kanwal* : Linear Integral Equations : Theory and Techniques, Academic Press, New York, 1971.
2. *S.G. Mikhlin* : Linear Integral Equations (translated from Russian), Hindustan Book Agency, 1969.
3. *I. Stakgold* : Boundary Value Problems of Mathematical Physics, Vols. I & II, Mac Millan, 1969.
4. *M.D. Raisighania* : Integral Equations and Boundary Value Problems, S. Chand & Co.

Paper V – OPTIONAL PAPER M.M. : 90

CHOOSE ANY ONE OF THE FOLLOWING PAPERS :

Paper V(*a*) – FUNDAMENTALS OF COMPUTER SCIENCE

Object oriented Programming - Classes and Scope, nested classes, pointer class members; Class initialization, assignment and destruction; Overloaded functions and operators; Templates including class templates; class inheritance and subtyping, multiple and virtual inheritance.

Data Structure - Analysis of Algorithms, q, W, 0, o, w notations, Lists, Stacks and queues, Sequential and linked representations, Trees, Binary tree - search tree implementation, B-tree (concept only), Hashing - open and closed, Sorting, Insertion sort, shell sort, quick-sort, head sort and their analysis.

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Database Systems - Role of database systems, database system, architecture, Introduction to relational algebra and relational calculus, SQL - basic features including views, Integrity constraints, Database design - normalization upto BCNF.

Operating Systems - User interface, Processor, management, I/O management, memory management, concurrency and security, network and distributed systems.

References :

1. *S.B. Lipman, J. Lajoi*: C ++ Primer, Addison Wesley.
2. *B. Stroustrup,* The C++ Programming Language, Addison Wesley.
3. *C.J. Date,* Introduction to Database System, Addison Wesley.

Paper V(*b*) – PARTIAL DIFFERENTIAL EQUATIONS & MECHANICS

Partial Differential Equations - Examples of PDE, Classification.

Transport Equation - Initial value Problem, Non-homogeneous Equation

Laplace's Equation - Fundamental Solution, Mean Value Formula, 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.

Mechanics (Analytical Dynamics).

Generalized co-ordinates, Holonomic and Non-holonomic systems, Scleronomic and Rheonomic systems, Generalized potential, Lagrange's Equations of first kind, Lagrange's equations of second kind, Uniqueness of solution, Energy equation for conservative fields.

Hamilton's variables, Donkin's Theorem, Hamilton canonical equations, Cycle co-ordinates, Routh's equations, Poisson's Bracket, Poisson's Identity, Jacobi-Poisson Theorem, Shortest Distance, Minimum surface of revolution, Brachistochrone problem, Isoprimetric problems, Geodesic.

Hamilton's Principle, Principle of least action, Poincare Cartan Integral Invariant, Whittaker's equations, Jacobi's Equations, Statement of Lee Hwa Chung's theorem.

Hamilton-Jacobi equation, Jacobi theorem, Method of separation of variables, Lagrange's Brackets, Condition of canonical character of a transformation in terms of Lagrange's brackets and Poisson Brackets, Invariance of Lagrange's brackets and Poisson brackets under canonical transformations.

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References :

1. *L.C. Evans*, Partial Differential Equations, Graduate Studies in Mathematics, Vol. - 19, AMS, 1996.
2. *F. Gantmacher*, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
3. *N.C. Rana & P.S.C. Joag*, Classical Mechanics, Tata MacGraw Hill, 1991.
4. *L.N. Hand and J.D. Finch*, Analytical Mechanics, Cambridge University Press, 1998.

Paper V(*c*) – SPACE DYNAMICS

Basic Formulae of a Spherical triangle - The Two-body Problem, The Motion of the Centre of Mass, The relative motion, Kepler's equation, Solution by Hamilton Jacobian theory.

The Determination of Orbits - Laplace's Gauss Methods.

The Three Body problem - General Theory Problem, Restricted Three Body Problem, Jacobian Integral, Curves of Zero velocity, Stationary solutions and their stability.

The n-Body Problem - The motion of centre of mass, Classical integrals.

Perturbation - Osculating orbit, Perturbing forces, Secular & Periodic perturbations, Lagrange's Planetary Equations in terms of perturbing forces and in terms of perturbed Hamiltonian.

Motion of the Moon - The perturbing forces, Perturbations of Keplerian elements of the Moon by the Sun.

Flight Mechanics - Rocket Performance in a Vacuum, Vertically ascending paths, Gravity Twin trajectories, Multi-stage rocket in Vacuum, Definitions pertinent to single stage rocket, Performance limitations of single stage rockets, Definitions pertinent to multi-stage rockets, Analysis of multi-stage rockets neglecting gravity, Analysis of multi-stage rockets including gravity.

Rocket Performance with Aerodynamic forces.

Short range non-lifting missiles, Ascent of sounding rocket, Some approximate performance of rocket-powered air-craft.

References :

1. *J.M.A. Danby*, Fundamentals of Celestial Mechanics, Macmillan Company, 1962.
2. *E. Finlay & Freundech*, Celestial Mechanics, The Macmillan Company, 1958.

Paper V(*d*) – NON-LINEAR PROGRAMMING

The non-linear Programming problem and its fundamental ingredients.

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Linear inequalities and theorems of the alternative - Kapler's Theorem, The Optimality criteria of linear programming, Tucker's lemma and existence theorems, Theorems of the alternative.

Convex sets - Separation theorems.

Convex and Concave functions - Basic properties and some fundamental theorems for convex functions, Generalized Gordan theorem, Bohnenblust-Karlin-Shapley theorem.

Saddle point Optimality criteria without differentiability - The minimization and the local minimization problems and some basic results, Sufficient Optimality theorem, Fritz John saddle point necessary optimality theorem, Slater's and Karlin's Constraint qualifications and their equivalence, The strict constraint qualification, Kuhn-Tucker Saddle point necessary optimality theorems.

Differentiable Convex and Concave functions - Some basic properties, Twice differentiable convex and concave functions, Theorems in cases of strict convexity and concavity of function.

Optimality criteria with differentiability - Sufficient optimality theorems, Firtz John Stationary point necessary optimality theorem, The Arrow-Hurwie-Uzawa Constraint qualification, Kuhn-Tucker stationary point necessary optimality theorem.

Duality in non-linear programming - Weak duality theorem, Wolfe's duality theorem, Strict converse duality theorem, the Hanson-Huard strict converse duality theorem, Unbounded dual theorem, Duality in quadratic and linear programmings.

Quasi-convex, Strictly quasi-convex functions - Differentiability properties, Strictly quasi-convex and strictly quasi-concave functions, Karamardian theorem, Global minimum (maximum).

Pseudo-convex and pseudo-concave functions, Relationship between pseudo-convex functions and strictly quasi-convex functions.

Optimality, and duality for generalized convex and concave functions - Sufficient optimality theorem, Generalized Kuhn-Tucker Sufficient Optimality theorem, Generalized Fritz John Stationary point necessary optimality theorem, Kuhn-Tucker necessary optimality conditions under the weak constraint qualification, Duality.

Optimality and duality in the presence of non-linear equality constraints- Sufficient Optimality criteria, Minimum principle necessary optimality criteria : X^0 not open, Minimum principle necessary optimality theorem, Fritz, John and Kuhn-Tucker Stationary point necessary optimality criteria : X^0 Open, Duality with non-linear equality constraints.

References :

1. *O.L. Mangasarian*, Non-linear Programming, McGraw Hill, New York.
2. *Mokhtar S. Bazaraa* and C.M. Shetty, Non-linear Programming, Theory and Algorithms, Wiley, New York.

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Paper V(*e*) – SPECIAL FUNCTIONS

Analytical study of Beta and Gamma Functions with complex arguments, Hypergeometric Functions, Generalized Hypergeometric Functions and Confluent Hypergeometric Functions, Legendre and Bessel Functions with complex arguments.

Laguerre Polynomials, Hermite Polynomials, Orthogonal Sets of Functions, Elliptic Functions of Weierstrass and Jacobi including Theta functions, Jacobi Polynomials, The Dirac-Delta function, Chebyshev Polynomials.

References :

1. *Rainvelle, E.D.* : Special Functions, Chelsea Publishing Co., 1971.
2. *Saran N., S.D. Sharma & Trivedi T.N.* : Special Functions, Pragati Prakashan, Meerut.
3. *M.A. Pathan, V.B.L. Chaurasia, P.K. Banerji & M.C. Goyal* : Special Functions and Calculus of Variations, Indus Valley Publications, New Delhi, 2004 (Hard Cover), and Ramesh Book Depot, New Delhi and Jaipur.

Paper V(*f*) – GENERAL RELATIVITY & COSMOLOGY

Riemannian metric, Parallel transport, Intrinsic derivative and geodesics, Riemann Christoffel curvature tensor and its symmetry properties, Bianchi identities and Einstein tensor.

Review of the special theory of relativity and the Newtonian Theory of gravitation, Principle of equivalence and general covariance, Geodesic principle, Newtonian approximation of relativistic equations of motion, Einstein's field equations and its Newtonian approximation.

Schwarzschild external solution and its isotropic form, Planetary orbits and analogues of Kepler's Laws in general relativity, Advance of perihelion of a planet, Bending of light rays in a Gravitational field, Gravitational redshifts of spectral lines, Radar echo delay.

Energy - Momentum tensor of a perfect fluid, Schwarzechild internal solution, Boundary conditions, Energy momentum tensor of an electromagnetic field, Einstein-Maxwell equations, Reissner-Nordstrom solution.

Cosmology - Mach's principle, Einstein modified field equations with cosmological term, Static cosmological models of Einstein and De-Sitter, their derivation properties and comparison with the actual universe.

Hubble's Law, Cosmological principles, Weyl's postulate, Derivation of Robertson-Walker metric, Hubble and deacceleration parameters, Redshifts, Redshift versus distance relation, Angular size versus redshift relation and source counts in Robertson-Walker space - time.

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Friedmann models, Fundamental equation of dynamical cosmology, Critical density, Closed and open Universe, Age of the Universes Matter dominated era of the Universe, Einstein- de-Sitter model, Particle and even horizons.

Eddington-Lamaitre models with I-term, Perfect cosmological principle, Steady state cosmology.

References :

1. *A.S. Eddington*, The Mathematical Theory of Relativity, Cambridge University Press, 1965.
2. *J.V. Narlikar*, General Relativity and Cosmology, The Macmillan Company of India Limited, 1978.
3. *B.F. Shutz*, A First Course in General Relativity, Cambridge University Press, 1990.

Paper V(*g*) – BANACH ALGEBRAS

Definition of Banach Algebra and examples. Singular and Non-singular elements, The abstract index, The spectrum of an element, The spectral radius, Gelfand formula, Multiplicative linear functional & the maximum ideal space, Gleason-Kahane-Zelazko Theorem.

The Gelfand Transforms, The Spectral Mapping Theorem, Isometric Gelfand Transform, Maximal ideal spaces for Disc Algebra and the algebra 1, (*z*).

C^*-algebras - Definition and examples, Self adjoint, unitary, normal positive and projection elements in C^*-algebra, Commutative C^*-algebras, C^*-Homomorphisms, Representation of Commutative C^*-algebras, Sub-algebras and the spectrum, The spectral theorem, The continuous functional calculus, Positive linear functional and states in C^*-algebras, The GNS construction.

Strong and weak operator topologies, Von Neumann Algebras, Monotone Sequence of Operators, Range Projections, The Commutant, The Double Commutant theorem, The Keplansky Density Theorem, L^∞ as Von Neumann Algebra, Maximal Abelian Algebras.

Abelian Von Neumann Algebras, Cyclic and Separating vectors, Representation of Abelian Von Neumann Algebras, The L^∞ functional calculus, Connectedness of the unitary Group, The Projection lattice, Keplansky's formula, The centre of Von Neumann Algebra, Various types of projections, Centrally Orthogonal projections, Type Decomposition.

References :

1. *T.W. Palmer*, Banach, Algebra Vol. I., Cambridge University Press, 1964.
2. *C.E. Reckart*, General Theory of Banach Algebras, Von Nostrand, 1960.

Paper V(*h*) – FUZZY SETS AND THEIR APPLICATIONS

Fuzzy sets - Basic definitions, a - level sets, Convex fuzzy sets, Basic operation on fuzzy sets, Type of fuzzy sets, Cartesian products, Algebraic products, bounded sum and difference, *t*-norms and *t*-conorms.

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The Extension Principle - The Zedeh's extention principle, Image and inverse image of fuzzy sets, Fuzzy numbers, Elements of fuzzy arithmetic.

Fuzzy Relations and Fuzzy Graphs - Fuzzy relations on fuzzy sets, Composition of Fuzzy relations, Min. Max. composition and its properties, Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy relation equations, Fuzzy graphs, Similarity relation.

Possibility theory - Fuzzy measures, Evidence theory, Necessity measure, Possibility measure, Possibility distribution, Possibility theory and fuzzy sets, Possibility theory versus probability theory.

Fuzzy Logic - An overview of classical logic, Multi-valued logics, Fuzzy propositions, Fuzzy quantifiers, Linguistic variables and hedges, Inference form conditional Fuzzy propositions, the compositional rule of inference.

Approximate Reasoning - An overview of Fuzzy expert system, Fuzzy implications and their selection, Multi-conditional approximate reasoning, the role of fuzzy relation equation.

An introduction to Fuzzy Control - Fuzzy controllers, Fuzzy rule base, Fuzzy inference engine, Fuzzification, Defuzzification and the various defuzzification methods (the centre of area, the centre of maxima and the mean of maxima methods).

Decision making in Fuzzy Environment - Individual decision making, Multi-person decision making, Multi-criteria decision making, Multi-stage decision making, Fuzzy ranking methods, Fuzzy linear programming.

Reference :

1. *H.J. Zimmermann,* Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
2. *G.J. Klir and B. Yuan,* Fuzzy Sets and Fuzzy Logic, Prentice-Hall of India, New Delhi, 1995.

Paper V(*i*) – WAVELETS

Different ways of constructing wavelets - Orthonormal bases generated by a single function, the Balian-Low theorem, Smooth projection on $\mathbf{L}^2(\mathbf{R})$, Local sine and cosine bases and the construction of some wavelets, the unitary folding operators and the smooth projections, Multi-resolution analysis and construction of wavelets, Construction of compactly supported wavelets and estimates for its smoothness, Band limited wavelets, Orthonormality, Completeneses, Characterization of Lemarie-Meyer wavelets and some other characterizations, Franklin wavelets and Spline wavelets on the real line, Orthonormal bases of piecewise linear continuous functions for $\mathbf{L}^2(\mathbf{T})$, Orthonormal bases of periodic splines, Periodization of wavelets defined on the real line.

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Characterization in the theory of wavelets - The basic equations and some of its applications, Characterizations of MRA wavelets, Low pass filters and scaling functions, Non-existence of smooth wavelets in $\mathbf{H^2}$ (R).

Frames - The reconstruction formula and the Balian-Low theorem for frames, Frames from translations and dilations, Smooth frames for $\mathbf{H^2}$ (R).

Discrete transforms and algorithms - The discrete and the fast Fourier transforms, The discrete and the fast cosine transforms, The discrete version of the local sine and cosine bases, Decomposition and reconstruction algorithms for wavelets.

References :

1. *Eugenio Hernandez and Guido Weiss*, A First Course on Wavelets, CRC, Press, New York, 1996.
2. *G.K. Chui*, An Introduction to Wavelets, Academic Press, 1992.
3. *I. Daubechies*, Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.

Paper V(*j*) – NON-COMMUTATIVE RINGS

Tensor Products, Chain Conditions, Semisimplicity and Structure of semisimple rings (Wedderburn Artin Theory), Jacobian Radical, Prime radical, Prime and semiprime rings, Structure of primitive rings and Density Theorem, Direct products, Subdirect sums and Commutativity Theorems.

Division rings, Maximal subfields, Polynomials over division rings, Local Rings, Semi Local Rings and idempotents, Perfect and semiperfect rings.

References :

1. *T.Y. Law*, Non-Commulative Rings, Springer Verlag, 1991.
2. *I.N. Herstein*, Non-Commulative Rings, Carus Monographs of AMS, 1968.
3. *N. Jacobson*, Basic Algebra - II, W.H. Freeman, 1939.

Paper V(*k*) – THEORY OF LINEAR OPERATORS

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators, Properties of resolvent and spectrum, Spectral mapping theorem for polynomials, Spectral radius of a bounded linear operator on a complex Banach space, Elementary theory of Banach algebras.

General properties of compact linear operators, Spectral properties of compact linear operators on normed spaces, Behaviours of compact linear operators with respect to solvability of operator equations, Fredholm type theorems, Fredholm alternative theorem, Fredholm alternative for integral equations.

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Spectral properties of bounded self - Adjoint linear operators on a complex Hilbert space, Positive operators, Monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space, Square roots of a positive operator, Projection operators, Spectral family of a bounded self-adjoint linear operator and its properties, Spectral representation of bounded self-adjoint linear operators, Spectral theorem.

Spectral measures, Spectral Integrals, Regular Spectral Measures, Real and Complex Spectral Measures, Complex Spectral Integrals, Description of the Spectral Subspaces, Characterization of the Spectral Subspaces, The Spectral theorem for bounded normal Operators.

Unbounded linear operators in Hilbert space, Hellinger-Toeplitz theorem, Hilbert adjoint operators, Symmetric and self-adjoint linear operators, Closed linear operators and closures, Spectrum of an unbounded self-adjoint linear operator, Spectral theorem for unitary and self-adjoint linear operators, Multiplication operator and Differentiation Operator.

References :

1. *P.R. Halmos*, Introduction to Hilbert Space and the Theory of Spectral Multiplicity, Second-Edition, Chelsea Publishing Co, N.Y. 1957.
2. *N. Dunford and J.T. Schwartz*, Linear Operators - 3 Parts, Interscience/Wiley, New York, 1958-71.
3. *N.I. Ahhiezer and I.M.Glazman*, Theory of Linear Operators in Hilbert Space, Frederick Ungar Pub.Co., N.Y., Vol. I (1961), Vol. II (1963).
4. *P.R. Halmos*, A Hilbert Space Problem Book, D. Van Nostrand Company Inc., 1967.

Paper V(*l*) – BIOMECHANICS

(**Prerequisite :** Fluid Mechanics).

Newton's equations of motion, Mathematical modeling, Continuum approach, Segmental Movement and Vibrations.

External Flow : Fluid Dynamic Forces Acting on Moving Bodies.

Flying and Swimming.

Blood Flow in Heart, Lung, Arteries, and Veins.

Micro and Macro circulation.

Respiratory Gas Flow.

The Laws of Thermodynamics, Molecular Diffusion, Mechanisms in Membranes, and Multiphasic Structure.

Mass Transport in Capillaries, Tissues, Interstitial Space, Lymphatics, Indicator Dilution Method, and Peristalsis.

Description of Internal Deformation and Forces.

Stress, Strain, and Stability of Organs.

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Strength, Trauma, and Tolerance.

Biomechanical Aspects of Growth, Engineering of Blood Vessels, Tissue Engineering of Skin.

Reference :

1. *Y.C. Fung,* Biomechanics, Springer-Verlag, New York, Inc., 1990.

Paper V(*m*) – ANALYTIC NUMBER THEORY

(**Prerequisite :** Elementary Number Theory and Complex Analysis)

Riemann Zeta function, Functional equation, prime number theorem, arithmetical functions, Mobvious inversion, introduction to modular forms.

References :

1. *T.M. Apostol,* Introduction to Analytic Number Theory, Narosa Publishing House, 1980.

2. *J.P. Serre,* A Course in Arithmetic, GTM Vol. 7, Springer-Verlag, 1973.

Paper V(*n*) – ALGEBRAIC NUMBER THEORY

(**Prerequisite :** Elementary Algebra & Number Theory)

Algebraic number fields and their rings of integers, calculations for quadratic and cubic cases, Localization, Galois extensions, Dedekind rings, Discrete valuation rings, Completion, unramified and ramified extensions, different, discriminant, cyclotomic fields, roots of unity, Class group and the finiteness of the class number, Dirichlet unit theorem, Pell equation, Dedekind and Riemann zeta functions, analytic class number formula.

References :

1. *S. Lang,* Algebraic Number Theory, GTM Vol. 110 Springer-Verlag, 1994.

2. *J. Esmonde and M. Ram Murty,* Problems in Algebraic Number Theory, GTM Vol. 190 Springer-Verlag 1999.

Project Work & Viva Voce. M.M. : 50

Every student shall choose a topic *related to* the syllabus of Mathematics prescribed for M.A./M.Sc. (Final) *in or around the first week of December* and shall prepare a Project comprising of, *neatly handwritten* or *typed*, 20 to 30 pages of A-4 size after consultation with the *subject teacher*. The first page of the Project shall consist of the name of the *College* and *Department*, *Academic session*, *Title of the Project*, *Name of the student* including his/her *Class* and *Roll No.* (if available). The project should be **signed by the student and checked by the teacher**. Out of 50 marks, 20 marks shall be for the Project and remaining 30 marks for viva on the Project as-well-as on the entire syllabus of Mathematics for M.A./M.Sc. (Final). At the time of Viva Examination, the student shall present his/her Project on the black board or through Power Point.

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