Scheme of instructions for M.Sc (Mathematics)

Semester I

S.No	Course Code	Course title	Mode			Credits	Assessment	
			L	P	T		Internal (%)	End Sem (%)
1	MA101C	Algebra	3	0	1	4	40	60
2	MA102C	Real Analysis	3	0	1	4	40	60
3	MA103C	Linear Algebra	3	0	1	4	40	60
4	MA104C	Ordinary Differential Equations	3	0	1	4	40	60
5	MA105C	Discrete Mathematics	3	0	1	4	40	60
6	MA106P	Programming Laboratory	1	1	0	2	40	60
7		Open Elective				3	40	60
		TOTAL CREDITS				**25**		

Semester II

S.No	Course Code	Course title	Mode			Credits	Assessment	
			L	P	T		Internal (%)	End Sem (%)
1	MA201C	Topology	3	0	1	4	40	60
2	MA202C	Complex Analysis	3	0	1	4	40	60
3	MA203C	Numerical Analysis	3	0	1	4	40	60
4	MA204C	Partial Differential Equations	3	0	1	4	40	60
5	MA205C	Probability & Statistics	3	0	1	4	40	60
6	MA206P	Computing Laboratory-I	1	1	0	2	40	60
7	MA207E	Soft Elective	3	0	0	3	40	60
		TOTAL CREDITS				**25**		

Semester III

S.No	Course Code	Course title	Mode			Credits	Assessment	
			L	P	T		Internal (%)	End Sem (%)
1	MA301C	Functional Analysis	3	0	1	4	40	60
2	MA302C	Transformation Techniques	3	0	1	4	40	60
3	MA303C	Fluid Mechanics	3	0	1	4	40	60
4	MA304E	Elective-I	3	0	1	4	40	60
5	MA305E	Elective-II	3	0	1	4	40	60
6	MA306P	Computing Laboratory-II	1	1	0	2	40	60
7	MA307S	Seminar				2	40	60
		TOTAL CREDITS				**24**		

Semester IV

S.No	Course Code	Course title	Mode			Credits	Assessment	
			L	P	T		Internal (%)	End Sem (%)
1	MA401C	Measure & Integration	3	0	1	4	40	60
2	MA402C	Operations Research	3	0	1	4	40	60
3	MA403E	Elective-III	3	0	1	4	40	60
4	MA404E	Elective-IV	3	0	1	4	40	60
5	MA405P	Computing Laboratory-III	1	1	0	2	40	60
6	MA406D	Project Work (Dissertation)				6	40	60
7	MA407V	Comprehensive Viva				2		100
		TOTAL CREDITS				**26**		

TOTAL NUMBER OF CREDITS FOR THE PROGRAMME IS 100

Abbreviations

L Lectures
P Practicals
T Tutorials
C Core

E Electives
S Seminars
V Viva
D Dissertation

List of Soft Electives

1) History of Mathematics & Mathematicians
2) Elementary Mathematical Modeling
3) Coordinate Geometry
4) Elements of Calculus
5) Elementary Number Theory

List of Electives

Elective-I

1) Advanced Algebra
2) Classical Mechanics
3) Number Theory
4) Mathematical Modeling
5) Special Functions

Elective-II

1) Finite Difference Methods
2) Differential Geometry
3) Graph Theory
4) Design & Analysis of Algorithms
5) Continuum Mechanics

Elective-III

1) Finite Element Method
2) Computational Fluid Dynamics
3) Advanced Operations Research
4) Theory of Automata
5) Riemannian Geometry

Elective-IV

1) Calculus of Variations & Integral Equations
2) Cryptography
3) Object Oriented Programming
4) Financial Mathematics
5) Algebraic Topology

SYLLUBUS FOR M.Sc. MATHEMATICS

MA101C: ALGEBRA

Recapitulation(Self-study/Seminar): Groups, Subgroups, Cyclic groups, Normal Subgroups, Quotient groups, Homomorphism, Types of homomorphisms.

Permutation groups, symmetric groups, cycles and alternating groups, dihedral groups, Isomorphism theorems and its related problems, Automorphisms, Inner automorphisms, groups of automorphisms and inner automorphisms and their relation with centre of a group.

Group action on a set, Orbits and Stabilizers, The orbit-stabilizer theorem, The Cauchy-Frobenius lemma, Conjugacy, Normalizers and Centralizers, Class equation of a finite group and its applications.

Sylow's groups and subgroups, Sylow's theorems for a finite group, Applications and examples of p-Sylow subgroups.

Solvable groups, Simple groups, Applications and examples of solvable and simple groups, Jordan –Holder Theorem.

Recapitulation(Self-study/Seminar): Rings, Some special classes of rings (Integral domain, division ring, field).

Homomorphisms of rings, Kernel and image of Homomorphisms of rings, Isomorphism of rings, Ideals and Quotient rings, Fundamental theorem of homomorphism of rings.

Theorems on principle, maximal and prime ideals, Field of quotients of an integral domain, Imbedding of rings.

Euclidean rings, Prime and relatively prime elements of a Euclidean ring, Unique factorization theorem, Fermat's theorem, Polynomial rings, The division algorithm.

Polynomials over the rational field, Primitive polynomial, Content of a polynomial. Gauss lemma, Eisenstein criteria, Polynomial rings over commutative rings, Unique Factorization Domains.

TEXT BOOKS

1. I. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley and Sons, 2007.
2. Surjeet Singh and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House, 1994.
3. N. Jacobson , Basic Algebra-I, 2nd ed., Dover Publications, 2009.

REFERENCE BOOKS

1. M. Artin : Algebra, Prentice Hall of India, 1991.
2. Darek F. Holt, Bettina Eick and Eamonaa. Obrien. Handbook of computational group theory, Chapman & Hall/CRC Press, 2005
3. J. B. Fraleigh : A first course in abstract algebra, 7th ed., Addison-Wesley Longman, 2002.

MA102C: REAL ANALYSIS

The Riemann – Stieltjes Integral: Definitions and existence of the integral, Linear properties of the integral, the integral as the limit of sums, Integration and Differentiation, Integration of vector valued functions. Functions of bounded variation – First and second mean value Theorems, Change of variable rectifiable curves.

Sequence and series of Functions: Pointwise and Uniform Convergence, Cauchy Criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and Riemann – Stieltjes Integration, Uniform convergence and Differentiation. Uniform convergence and bounded variation-Equacontinous families functions, uniform convergence and boundedness, The stone-Weierstrass theorem and Weierstrass approximation of continuous function, illustration of theorem with examples-properties of power series, exponential and logarithmic functions, trigonometric functions. Topology of Rn, K-cell and its compactness, Heine-Borel Theorem. Bolzano Weierstrass theorem, Continuity, Compactness and uniform continuity.

Functions of several variables, continuity and Differentiation of vector-valued functions, Linear transformation of Rk properties and invertibility, Directional Derivative, Chain rule, Partial derivative, Hessian matrix. The Inverse Functions Theorem and its illustrations with examples. The Implicit Function Theorem and illustration and examples. The Rank theorem illustration and examples.

TEXT BOOKS

1. W. Rudin : Principles of Mathematical Analysis, McGraw Hill, 1983.
2. T. M. Apostol: Mathematical Analysis, New Delhi, Narosa, 2004.
3. B. S.Thomson, A. M. Bruckner and J. B.Bruner: Real Analysis, Prentice Hall International, 2008.

REFERENCE BOOKS

1. S. Goldberg: Methods of Real Analysis, Oxford & IBH, 1970.
2. J. Dieudonne: Treatise on Analysis, Vol. I, Academic Press, 1960.

MA103C: LINEAR ALGEBRA

Systems of linear equations, matrices, elementary row operations, rank, uniqueness of echelon forms, Moore - Penrose Generalised inverse.

Vector spaces, subspaces, bases and dimension, coordinates.

Linear transformations and its algebra and representation by matrices, algebra of polynomials, determinant functions, permutation and uniqueness of determinants, additional properties.

Elementary canonical forms, characteristic values and vectors, Cayley Hamilton's theorem, annihilating polynomial, invariant subspaces. Simultaneous triangularisation, simultaneous diagonalisation, Jordan form.

Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators, Rayleigh quotient, Min-Max Principle

Bilinear forms, symmetric and skewsymmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

TEXT BOOKS

1. Hoffman and Kunze, *Linear Algebra*, Prentice Hall of India, New Delhi, 2003
2. P.G. Bhattacharya, S.K. Jain and S.R. Nagpaul, *First course in Linear Algebra*, Wiley Eastern Ltd., New Delhi, 1991
3. S. Lang, Linear Algebra, Undergraduate Texts in Mathematics, Springer-Verlag, New York, 1989.

REFERENCE BOOKS

1. V. Krishnamurthy et. Al., *An introduction to linear algebra*, Affiliated East West Press, New Delhi, 2003
2. M. Artin, Algebra, Prentice Hall of India, 1994.
3. K.B.Datta, *Matrix and Linear Algebra*, Prentice Hall of India, New Delhi, 2006

MA104C: ORDINARY DIFFERENTIAL EQUATIONS

Linear differential equations of nth order, fundamental sets of solutions, Wronskian –Abel's identity, theorems on linear dependence of solutions, adjoint – self - adjoint linear operator, Green's formula, Adjoint equations, the nth order non-homogeneous linear equations- Variation of parameters - zeros of solutions – comparison and separation theorems.

Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions, existence and uniqueness theorem for higher order and system of differential equations – Eigenvalue problems – Sturm-Liouville problems- Orthogonality of eigenfunctions - Eigenfunction expansion in a series of orthonormal functions- Green's function method.

Power series solution of linear differential equations- ordinary and singular points of differential equations, Classification into regular and irregular singular points; Series solution about an ordinary point and a regular singular point – Frobenius method- Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equationsand their general solutions. Generating function, Recurrence relations, Rodrigue's formula-Orthogonality properties. Behaviour of solution at irregular singular points and the point at infinity.

Linear system of homogeneous and non-homogeneous equations (matrix method) Linear and Non-linear autonomous system of equations - Phase plane - Critical points – stability Liapunov direct method – Limit cycle and periodic solutions-Bifurcation of plane autonomous systems.

TEXT BOOKS

1. G.F. Simmons : Differential Equations, TMH Edition, New Delhi, 1974.
2. M.S.P. Eastham : Theory of ordinary differential equations, Van Nostrand, London, 1970.
3. S.L.. Ross: Differential equations (3rd edition), John Wiley & Sons, NewYork, 1984.

REFERENCE BOOKS

1. S. G. Deo and V. Raghavendra, Ordinary differential equations, Tata McGraw Hill, New Delhi, 2006.
2. E.D. Rainville and P.E. Bedient : Elementary Differential Equations, McGraw Hill, NewYork, 1969.
3. E.A. Coddington and N. Levinson : Theory of ordinary differential equations, McGraw .Hill, 1955.
4. A.C.King, J.Billingham and S.R.Otto: 'Differential equations', Cambridge University Press, 2006.

MA105C: DISCRETE MATHEMATICS

Sets and propositions: Combinations of sets, Finite and Infinite sets, uncountably infinite sets, principle of inclusion and exclusion, mathematical induction. Propositions, fundamentals of logic, first order logic, ordered sets.

Permutations, combinations, numeric functions, generating functions.

Recurrence relations and recursive algorithms: recurrence relations, linear recurrence relations with constant coefficients, homogeneous solutions, particular solutions, total solutions, solution by the method of generating functions, sorting algorithm.

Relations and functions: properties of binary relations, equivalence relations and partitions, partial and total ordering relations, Transitive closure and Warshal's algorithm.

Boolean algebra : Chains, Lattices and algebraic systems, principle of duality, basic properties of algebraic systems, distributive and complemented lattices, boolean lattices and algebras, uniqueness of finite boolean algebras, boolean expressions and functions.

Graphs and planar graphs : Basic terminology, multigraphs and weighted graphs, paths and circuits, shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Colourable graphs, Chromatic numbers, Five colour theorem and Four colour problem. Trees and cut-sets : trees, rooted trees, path lengths in rooted trees, spanning trees and BFS & DFS algorithms, minimum spanning trees and Prims & Kruskal's algorithms.

TEXT BOOKS

1. Mott, Kandel and Baker, Discrete Mathematics for Computer Scientists, PHI, 2006.
2. C.L.LIU, Elements of Discrete Mathematics, McGraw Hill, 1985.

REFERENCE BOOKS

1. J. P. Tremblay and R. P. Manohar, Discrete Mathematical Structures with applications to Computer Science, McGraw Hill, 2004.
2. F. Harary: Graph theory, Addition Wesley, 1969.
3. J. H. Van Lint and R. M. Wilson, "'A course on Combinatorics", Cambridge University Press (2006).

MA106P: PROGRAMMING LABORATORY

- Basics & fundamentals of C Language
- Basic Programs using C Language
- 12-15 Programs on Linear Algebra using C Language

MA201C: TOPOLOGY

Finite and Infinite sets. Denumerable and Non denumerable sets, Countable and Uncountable sets. Equivalent sets. Concept of Cardinal numbers, Schroeder- Bernstein Theorem. Cardinal number of a power set – Addition of Cardinal numbers, Exponential of Cardinal numbers, Examples of Cardinal Arithmetic, Cantor's Theorem. Card X<Card P(X). Continuum Hypothesis. Zorn's lemma (statement only).

Definition of a metric. Bolzano – Weierstrass theorem. Open and closed balls. Cauchy and convergent sequences. Complete metric spaces. Continuity, Contraction mapping theorem. Banach fixed point theorem, Bounded and totally bounded sets. Cantor's Intersection Theorem. Nowhere dense sets. Baire's category theorem. Isometry. Embedding of a metric space in a complete metric space.

Topology: Definition and examples Open and closed sets. Neighborhoods and Limit Points. Closure, Interior and Boundary of a set. Relative topology. Bases and sub-bases. Continuity and Homeomorphism, Pasting lemma.

Connected spaces: Definition and examples, connected sets in the real line, Intermediate value theorem, components and path components, local connectedness and path connectedness.

TEXT BOOKS

1. J. R. Munkres, *Topology*, Second Edition, Prentice Hall of India, 2007
2. W.J. Pervin : Foundations of General Topology - Academic Press, 1964.

REFERENCE BOOKS

1. G. F. Simmons : Introduction to Topology and Modern Analysis – Tata Mc Graw Hill, 1963.
2. J. Dugundji : Topology - Prentice Hall of India, 1975
3. G J.L. Kelley, General Topology, Van Nostrand, Princeton, 1955.

MA202C: COMPLEX ANALYSIS

Analytic functions, Harmonic conjugates, Elementary functions, Mobius Transformation, Conformal mappings, Cauchy's Theorem and Integral formula, Morera's Theorem, Cauchy's Theorem for triangle, rectangle, Cauchy's Theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. Principles of analytic Continuation. Liouville's Theorem, Fundaments theorem of algebra**.**

Series, Uniform convergence, Power series, Radius of convergences, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series.

Rational Functions, Singularities, Poles, Classification of Singularities, Charecterisation of removable Singularities, poles. Behaviour of an Analytic functions at an essential singular point. Entire and Meromorphic functions.The Residue Theorem, Evaluation of Definite integrals, Argument principle, Rouche's Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications, Convex functions, Hadmard's Three circle theorem**.**

Phragmen-Lindelof theorem,The Riemann mapping theorem, Weistrass factorization theorem. Harmonic functions, Mean Value theorem. Poisson's formula, Poisson's Integral formula, Jensen's formula, Poisson's- Jensen's formula.

TEXT BOOKS

1. J. B. Conway : Functions of one complex variable, Narosa, 1987.
2. L.V. Ahlfors : Complex Analysis, McGraw Hill, 1986.
3. R.V. Churchill, Brown, Complex Variables and Applications. McGraw Hill, 1974.

REFERENCE BOOKS

1. R. Nevanlinna : Analystic functions, Springer, 1970.
2. E. Hille : Analytic Teory, Vol. I, Ginn, 1959.
3. S. Ponnaswamy : Functions of Complex variable, Narosa Publications

MA203C: NUMERICAL ANALYSIS

Principles of floating point computations, Errors: Roundoff error, Local truncation error, Global truncation error, order of a method, convergence and terminal conditions.

Interpolation : Existence, Uniqueness of interpolating polynomial, error of interpolation – unequally spaced data; Lagrange's, Newton's divided difference formulae. Equally spaced data : finite difference operators and their properties, Gauss's forward and backward formulae – Inverse interpolation – Hermite interpolation.

Differentiation : Finite difference approximations for first and second order derivatives.

Integration : Newton-cotes closed type methods; particular cases, error terms – Newton cotes open type methods – Romberg integration, Gaussian quadrature; Legendre, Chebyshev formulae.

Solution of nonlinear and transcendental equations : Regula - Falsi, Newton-Raphson method, Chebyshev's, method, Muller's method, Birge-Vita method, solution of system of nonlinear equations.

Approximation :Norms, Least square (using monomials and orthogonal polynomials), uniform and Chebyshev approximations.

Solution of linear algebraic system of equations: LU Decomposition, Gauss-Seidal methods; solution of tridiagonal system. III conditioned equations.

Eigen values and eigen vectors : Power and Jacobi methods.

Solution of Ordinary differential equations: Initial value problems: Single step methods; Taylor's, Euler's, Runge-Kutta methods, error analysis; Multi-step methods: Adam - Bashforth, Nystorm's, Adams- Moulton methods, Milne's predictor-corrector methods. System of IVP's and higher order IVP's.

TEXT BOOKS

1. Jain, Iyengar and Jain, Numerical Methods for Engineers and Scientists, New Age International, 2008.
2. Gerald and Wheatley Applied Numerical Analysis, Addison-Wesley, 1984.
3. Atkinson, Numerical Analysis, John Wiley, Singapore, 1978.

REFERENCE BOOKS

1. S.S. Sastry: Introductory methods of Numerical analysis, Prentice- Hall of India, New Delhi (1998).
2. D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Blackwell Scientific Publications (1991).

MA204C: PARTIAL DIFFERENTIAL EQUATIONS

First Order Partial Differential Equations:- Basic definitions, Origin of PDEs, Classification, Geometrical interpretation. The Cauchy problem, the method of characteristics for Semi linear, quasi linear and Non-linear equations, complete integrals, Examples of equations to analytical dynamics, discontinuous solution and shockwaves.

Second Order Partial Differential Equations:- Definitions of Linear and Non-Linear equations, Linear Superposition principle, Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs, Reduction to canonical forms , solution of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge's method.

Wave equation:- Solution by the method of separation of variables and integral transforms The Cauchy problem, Wave equation in cylindrical and spherical polar co-ordinates.

Laplace equation:- Solution by the method of separation of variables and transforms. Dirichlet's, Neumann's and Churchills problems, Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates

Diffusion equation:-Fundamental solution by the method of variables and integral transforms, Duhamel's principle, Solution of the equation in cylindrical and spherical polar coordinates.

Solution of boundary value problems:- Green's function method for Hyperbolic, Parabolic and Elliptic equations.

TEXT BOOKS

1. I. N. SNEDDON, Elements of PDE's , McGraw Hill Book company Inc., 2006.
2. L DEBNATH , Nonlinear PDE's for Scientists and Engineers, Birkhauser , Boston, 2007.
3. F. John, Partial differential equations, Springer, 1971.

REFERENCE BOOKS

1. F. Treves: Basic linear partial differential equations, Academic Press, 1975.
2. M.G. Smith: Introduction to the theory of partial differential equations, Van Nostrand, 1967.
3. Shankar Rao: Partial Differential Equations, PHI, 2006.

MA205C: PROBABILITY & STATISTICS

Random variable and sample space – notion of probability – axioms of probability – empirical approach to probability – conditional probability – independent events – Bayes' Theorem – probability distributions with discrete and continuous random variables – joint probability mass function, marginal distribution function, joint density function.

Mathematical expectation – moment generating function – Chebyshev's inequality – weak law of large numbers – Bernoullian trials – the Binomial, negative binomial, geometric, Poisson, normal, rectangular, exponential, Gaussian, beta and gamma distributions and their moment generating functions – fit of a given theoretical model to an empirical data.

Sampling and large sample tests – Introduction to testing of hypothesis – tests of significance for large samples – chi-square test – SQC – analysis of variance – t and F tests – theory of estimation – characteristics of estimation – minimum variance unbiased estimator – method of maximum likelihood estimation.

Scatter diagram – linear and polynomial fitting by the method of least squares – linear correlation and linear regression – rank correlation – correlation of bivariate frequency distribution.

TEXT BOOKS

1. S.C. Gupta and V.K. Kapur, Fundamentals of Mathematical Statistics, S.Chand & Co., 2008.
2. U.K. Rohatgi and A.K. Md.Ehsanes Saleh, An Introduction to Probability theory and Mathematical Sciences, Wiley, 2001
3. R. A. Johnson, Miller and Freund's - Probability and Statistics for Engineers, PHI, 2011.

REFERENCE BOOKS

1. K.L. Chung, A Course in Probability Theory, Academic Press, New York, 1974.
2. E. Kreyszig, Advanced Engineering Mathematics, Wiley, 2011.

MA206P: Computing Laboratory – I

- Introduction to Opensource Softwares
- Basic Programming Using Opensource Softwares
- 12-15 Programs on Numerical Methods and Probability & Statistics listed below.

Numerical Analysis: Programs on Numerical methods for finding solution of Algebraic and Transcendental Equations. Programs on Numerical Differentiation and Numerical Integration. Programs on Numerical solutions of Differential Equations.

Probability and Statistics: Symbolic and numeric computation of probabilities and conditional probabilities of events as logical combinations of equations and inequalities. Symbolic and numeric computation of expectations and conditional expectations of expressions. Simulating distributions, estimating parameters in distributions, and testing goodness-of-fit for distributions. Generating functions associated with moments, including moment-generating functions and cumulant-generating functions. Conversion from between different types of moments. Computation of standard and unbiased moment estimators.

MA301C: FUNCTIONAL ANALYSIS

Normed linear spaces. Banach Spaces : Definition and examples. Quotient Spaces. Convexity of the closed unit sphere of a Banach Space. Examples of normed linear spaces which are not Banach. Holder's inequality. Minkowski's inequality. Linear transformations on a normed linear space and characterization of continuity of such transformations.

The set $B(N,N')$ of all bounded linear transformations of a normed linear space N into normed linear space N'. Linear functionals , The conjugate space N*. The natural imbedding of N into N**. Reflexive spaces.

Hahn -Banach theorem and its consequences, Projections on a Banach Space. The open mapping theorem and the closed graph theorem. The uniform boundedness theorem. The conjugate of an operator, properties of conjugate operator.

Inner product spaces, Hilbert Spaces: Definition and Examples, Schwarz's inequality. Parallelogram Law, polarization identity. Convex sets, a closed convex subset of a Hilbert Space contains a unique vector of the smallest norm.

Orthogonal sets in a Hilbert space. Bessel's inequality. orthogonal complements, complete orthonormal sets, Orthogonal decomposition of a Hilbert space. Characterization of complete orthonormal set. Gram-Schmidt orthogonalization process.

The conjugate space H* of a Hilbert space H. Representation of a functional f as f(x) = (x, y) with y unique. The Hilbert space H*. Interpretation of T* as an operator on H. The adjoint operator T* on B (H). Self-adjoint operators, Positive operators. Normal operators. Unitary operators and their properties.

Projections on a Hilbert space. Invariant subspace. Orthogonality of projections. Eigen values and eigen space of an operator on a Hilbert Space. Spectrum of an operator on a finite dimensional Hilbert Space. Finite dimensional spectral theorem.

TEXT BOOKS

1. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw-Hill , 1998.

REFERENCE BOOKS

1. G. Backman and L. Narici : Functional Analysis (Academic), 2006.
2. B. V. Limaye : Functional Analysis (Wiley Eastern), 1998.
3. P.R. Halmos : Finite dimensional vector paces, Van Nostrand, 1958.
4. E. Kreyszig : Introduction to Functional Analysis with Applications, John Wiley & Sons, 2000.

MA302C: TRANFORMATION TECHNIQUES

Laplace Transform : Defnition – Functions of exponential order and examples – Transforms of elementary, transcendental and special functions – transforms of derivatives and integrals and periodic function, unit step function and impulse function – The inverse transform – Convolution theorem – solution of differential equations by the use of the transform – Laplace inverse integral

– Solution of Laplace equation (in two dimensions), one dimensional heat equation and one dimensional wave equation.

Fourier transform : The Fourier transform, Inverse Fourier transform, Fourier transform properties, Convolution integral, convolution theorem, correlation, correlation theorem, Parseval's theorem, Wave from sampling, sampling theorem, frequency sampling theorem.

Z transform : Z transform, inverse Z transform, Z transform properties, solution of linear difference equations by using Z transform.

Discrete Fourier Transform : Fourier transform of sequences, Discrete Fourier transform, transfer function.

The Fast Fourier Transform : Intuitive Development, Theoretical development of Base 2, FFT algorithm.

TEXT BOOKS

1. Churchill, Operational Mathematics, McGraw Hill, 1972.
2. Hildebrand, Methods of Applied Mathematics, PHI, New Jercy, 1960.
3. E.O.Brigham, The Fast Fourier Transforms, Prentice Hall, New Jersy, 1988.
4. E.I.Jury, Theory and applications of Z transform method, John Wiley, 1964.

REFERENCE BOOKS

1. R. K. Jain and S. R. K. Iyengar: Advanced Engineering Mathematics, Narosa Publishing House, 2002.
2. Erwyn Kreyszig : Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition.
3. B.S.Grewal : Higher Engineering Mathematics, Khanna Publications, Latest Edition.

MA303C: FLUID MECHANICS

Kinematics of fluids in motion: Real fluids and ideal fluids – velocity of a fluid at a point – stream lines and path lines – steady and unsteady flows – the velocity potential – the velocity vector – local and particle rates of change – the equation of continuity – acceleration of fluid – conditions at a rigid boundary.

Equations of motion of fluid: Euler's equations of motion – Bernoulli's equation – some flows involving axial symmetry – some special two-dimensional flows. Some three dimensional flows: Introduction – sources, sinks and doublets – axisymmetric flows – Stokes' stream function. The Milne-Thomson circle theorem – the theorem of Blasius – applications.

Viscous flows: Stress analysis in fluid motion – relations between stress and rate of strain – the coeffcient of viscocity and laminar flow – the Navier-Stokes' equations of motion of viscous fluid – steady motion between parallel planes, through tube of uniform cross section and flow between concentric rotating cylinders.

Steady viscous flow in tubes of uniform cross section – a uniqueness theorem – tube having uniform elliptic cross section – tube having equilateral triangular cross section – steady flow past a fixed sphere.

TEXT BOOKS

1. Frank Chorlton, Fluid Dynamics, CBS Publishers, Delhi, 2004
2. S. W. Yuan : Foundations of Fluid Mechanics, Prentice Hall, 1976.
3. C.S.Yih : Fluid Mechanics, McGraw-Hill, 1969.

REFERENCE BOOKS

1. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge, 2000.
2. D. Tritton, Physical Fluid Dynamics, Oxford.
3. L.M.Milne Thomson, Theoretical Hydrodynamics, Macmillan Company, New York, 1960

MA306P: Computing Laboratory – II

- Introduction to MATLAB Software
- Basics of MATLAB commands
- Basic MATLAB Programming
- SIMULINK
- GUI
- 10 -15 Programs on Finite Difference Methods, PDE & Fluid Mechanics using Matlab Software .

MA401C: MEASURE & INTEGRATION

Algebra of sets, sigma algebras, open subsets of the real line. F_σ and G_δ sets, Borel sets, Outer measure of a subset of R 'Lebesgue outer measure of a subset of R Existence, non-negativity and monotonicity of Lebesgue outer measure; Relation between Lebesgue outer measure and length of an interval; Countable subadditivity of Lebesgue outer measure; translation invariance.

(Lebesgue) measurable sets, (Lebesgue) measure; Complement, union, intersection and difference of measurable sets; denumerable union and intersection of measurable sets; countable additivity of measure; The class of measurable sets as a algebra, the measure of the intersection of a decreasing sequence of measurable sets.

Measurable functions; Scalar multiple, sum, difference and product of measurable functions. Measurability of a continuous function and measurability of a continuous image of measurable function. Convergence pointwise and convergence in measures of a sequence of measurable functions.

Lebesgue Integral; Characteristic function of a set; simple function; Lebesgue integral of a simple function; Lebesgue integral of a bounded measurable function; Lebesgue integral and Riemann integral of a bounded function defined on a closed interval; Lebesgue integral of a non-negative function; Lebesgue integral of a measurable function; Properties of Lebesgue integral.

Convergence Theorems and Lebesgue integral; The bounded convergence theorem; Fatou's Lemma: Monotone convergence theorem; Lebesgue convergence theorem.

Differentiation of Monotone functions. Vitali covering lemma. Functions of Bounded variation. Differentiability of an integral. Absolute continuity and indefinite integrals.

Lp spaces. Holder and Minkowski inequalities. Convergence and completeness, Riesz – Fischer Theorem. Bounded linear functionals Riesz representation theorem and illustrative examples. Measure spaces, Signed measures, the Radon Nikodyn theorem.

TEXT BOOKS

1. H.L. Royden : Real Analysis, Macmillan, 1963

REFERENCE BOOKS

1. P.R. Halmos : Measure Theory, East West Press, 1962
2. W. Rudin : Real & Complex Analysis, McGraw Hill , 1966

MA402C: OPERATIONS RESEARCH

Linear Programming : Lines and hyperplanes – convex sets, convex hull – Formulation of a Linear Programming Problem – Theorems dealing with vertices of feasible regions and optimality – Graphical solution – Simplex method (including Big M method and two phase method) – Dual problem – duality theory – dual simplex method – sensitivity analysis – revised simplex method – parametric programming .

Transportation problem – existence of solution – degeneracy – MODI method (including the theory).

Queuing theory: Characteristics of queueing systems – the birth and death process – steady state solutions – single server model (finite and infinite capacities) – single server model (with SIRO) – models with state dependent arrival and service rates waiting time distributions.

Inventory Control: Inventory control for single commodity – deterministic inventory models (without and with shortages) – Probabilistic inventory (both discrete and continuous) control models.

TEXT BOOKS

1. H.A.Taha , Operations Research, An Introduction , PHI, 2008
2. H.M.Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C.Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.

MA405P: Computing Laboratory – III

- Introduction to open source Software like scilab, maxima, octave, geogebraand etc.
- Introduction to Tecplot 360 CFD Software.
- Introduction to LATEX Software.
- 8-10 Programs on Operations Research, Computational Fluid Dynamics & Finite element method using Any Software.

MA207E: SOFT ELECTIVE

1. History of Mathematics & Mathematicians

Brief Biography of Euler, Fourier, Gauss, Able, Jacobi, Hilbert, Banach, Poincare, Galois, Laplace, Ramanujan and Lagrange.

Mathematics of Ancient Greeks: Pythagoras, Euclid, Archimedes.

The Arabs and the Development of Algebra : Introductory Remarks, The Development of Algebra – Al- Khwarizmi and the Basics of Algebra, The Life of Al- Khwarizmi, The Ideas of Al-Khwarizmi, Omar Khayyam and the Resolution of the Cubic.

Rene Descartes and the Idea of Coordinates : Introductory Remarks, The Life of Rene Descartes, The Real Number Line, The Cartesian Plane, Cartesian Coordinates and Euclidean Geometry, Coordinates in Three- Dimensional Space.

The Invention of Differential Calculus : The Life of Fermat, Fermat's Method, More Advanced Ideas of Calculus, The Derivative and the Tangent Line, Fermat's Lemma and Maximum/Minimum Problems.

Complex Numbers and Polynomials : A New Number System, Progenitors of the Complex Number System – Cardano, Euler, Argand, Cauchy, Riemann, Complex Number Basics, The Fundamental Theorem of Algebra, Finding the Roots of a Polynomial.

Cauchy and the Foundations of Analysis : Introduction, Properties of the Real Number System – Bounded Sequences, Maxima and Minima, The Intermediate Value Property.

The Number Systems : The Natural Numbers, The Integers, The Rational Numbers, The Real Numbers, The Complex Numbers.

Henri Poincare, Child Prodigy : Introductory Remarks, Rubber Sheet Geometry, The Idea of Homotopy, The Brouwar Fixed Point Theorem, The Generalized Ham Sandwich Theorem.

Methods of Proof : Axiomatics – Undefinables, Definitions, Axioms, Theorems, Modus Ponendo Ponens, and Modus Tollens, Proof by Induction, Proof by Contradiction, Direct Proof, Other Methods of Proof.

2. ELEMENTARY MATHEMATICAL MODELING

Meaning of first and second order ordinary derivatives – slope of a tangent and curvature. Connecting these concepts to practical observation.

Basic concepts. Real world problems, (Physics, Chemistry, Biology, Economics, and others) Approximation of the problem, Steps involved in modeling.

Mathematical models : Linear growth and decay model, Logistic model, model of Mass-spring-dashpot (present in shock absorbed, mechanical engineering problems), Chemical reaction, Drug absorption from blood stream. Motion of a projectile. Current flow in electrical circuits(LCR), Model for deduction of diabetes, Nonlinear system of equation- Combat models- predator- prey equations, spread of epidemics, Models leading to linear and nonlinear partial differential equations - Vibration of string, Vibration of drum, Heat equation and Laplace equation and Poisson equation, Burger's equation, Fisher's equation, Telegraph equations.

TEXT BOOKS

1.J. N. Kapur : Mathematical Moodelling, Wiley Eastern Ltd., 1998.
2.E. Kreyszig, Advanced Engineering Mathematics, Wileyeastem, 2002.

REFERENCE BOOKS

1. Neil Gerschenfeld : The nature of Mathematical modeling, Cambridge Univeristy Press, 1999.
2. A. C. Fowler : Mathematical Models in Applied Sciences, Cambridge Univeristy Press, 1997.

3. COORDINATE GEOMETRY

Preliminaries: Rectangular coordinates- Distance between two points- Division of a line joining two points in a given ratio - Angle between two lines- Direction cosines and ratios of a straight line- Condition for parallelism and perpendicularity of two lines- Projection of a line segment on another line. The plane- The general equation of the first degree in three variables always represents a plane surface-Direction cosines of the normal to a plane- Equation of a plane in intercept form- The form lx + my + nz = p - Angle between two planes- Pair of planes- Image of a point in a plane - Length of perpendicular from a point to a plane

The equation to a straight line- Symmetrical form- Parametric coordinates of any point on a line- Transformation from un-symmetrical form to the symmetric form- Condition for a line to be parallel to a plane- Angle between a line and a plane- Coplanar lines Lines intersecting two lines –Skew lines – Shortest distance between two lines.

The sphere- The equation of a sphere with given centre and radius- The equation of a sphere on the line joining two given points as diameter- Plane section of a sphere- Equation of a sphere passing through a given circle- The intersection of two spheres- The equation of a tangent plane to a sphere- Length of tangent to a sphere- Orthogonal spheres.

Hyperbolic functions- Inverse hyperbolic functions- Separation into real and imaginary parts.

TEXT BOOKS

1. S.L. Loney, The Elements of Coordinate Geometry, Macmillan India, 2010
2. R.J.T.Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan India, 1918

4. ELEMENTS OF CALCULUS

Differential Calculus: Rolle's theorem; Mean value theorem; Taylor's and Maclaurin's theorems with remainders, Expansions; Indeterminate forms; Asymptotes and curvature; Curve tracing; Functions of several variables, Partial Differentiation, Total Differentiation, Euler's theorem and generalization, maxima and minima of functions of several variables – Lagrange's method of Multipliers; Change of variables – Jacobians.

Integral Calculus: Fundamental theorem of integral calculus and mean value theorems; Evaluation of plane areas, volume and surface area of a solid of revolution and lengths. Convergence of Improper integrals – Beta and Gamma functions – properties – Differentiation under integral sign. Double and triple integrals – evaluation of surface areas and volumes – change of order of integration- change of variables in double and triple integrals.

Vector Calculus: Scalar and Vector fields; Vector Differentiation; Level surfaces – directional derivative - Gradient of scalar field; Divergence and Curl of a vector field - Laplacian - Line and surface integrals; Green's theorem in plane- Gauss Divergence theorem-Stokes' theorem (without proofs).

TEXT BOOKS

1. R.K.Jain and S.R.K.Iyengar: Advanced Engineering Mathematics, Narosa Publishing House, 2002.
2. Erwyn Kreyszig: Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition.

REFERENCE BOOKS

1. B.S.Grewal: Higher Engineering Mathematics, Khanna Publications, Latest Edition.

5. ELEMENTARY NUMBER THEORY:

Infinitude of primes, discussion of the Prime Number Theorem, infinitude of primes in specific arithmetic progressions, Dirichlet's theorem (without proof).

Arithmetic functions, Mobius inversion formula. Structure of units modulo n, Euler's phi function.

Congruences, theorems of Fermat and Euler, Wilson's theorem, linear congruences, quadratic residues, law of quadratic reciprocity.

Binary quadratics forms, equivalence, reduction, Fermat's two square theorem, Lagrange's four square theorem.

Continued fractions, rational approximations, Liouville's theorem, discussion of Roth's theorem, transcendental numbers, transcendence of "e" and "pi".

Diophantine equations: Brahmagupta's equation (also known as Pell's equation), the The equation, Fermat's method of descent, discussion of the Mordell equation.

TEXT BOOKS/ REFERENCE BOOKS

1. W.W. Adams and L.J. Goldstein, Introduction to the Theory of Numbers, 3rd ed., Wiley Eastern, 1972.
2. A. Baker, A Concise Introduction to the Theory of Numbers, Cambridge University Press, Cambridge, 1984.
3. I. Niven and H.S. Zuckerman, An Introduction to the Theory of Numbers, 4th Ed., Wiley, New York, 1980.

MA304E: Elective – I

1. ADVANCED ALGEBRA

Recapitulation: Rings, Some special classes of rings (Integral domain, division ring, field, maximal and prime ideals). The prime spectrum of a ring, the nil radical and Jacobson, radical, operation on ideals, extension and contraction.

Modules - Modules and modules homomorphisms, submodules and quotient modules, Direct sums, Free modules Finitely generated modules, Nakayama Lemma, Simple modules, Exact sequences of modules.

Modules with chain conditions - Artinian and Noetherian modules, modules of finite length, Artnian rings, Noetherian rings, Hilbert basis theorem.

Extension fields**,** Finite and Algebraic extensions. Degree of extension, Algebraic elements and algebraic extensions, Adjunction of an element of a field.

Roots of a polynomial, Splitting fields, Construction with straight edge and compass more about roots, Simple and separable extensions, Finite fields.

Elements of Galois Theory, Fixed fields, Normal extension, Galois groups over the rationals.

TEXT BOOKS

1. M. F. Atiyah and I. G. Macdonald – Introduction to Commutative Algebra, Addison-Wesley. (Part A)
2. I.N. Herstein : Topics in Algebra, 2nd Edition, Vikas Publishing House, 1976. (Part B)

REFERENCE BOOKS

1. C. Musili – Introduction to Rings and Modules, Narosa Publishing House, 1997.
2. Miles Reid – Under-graduate Commutative Algebra, Cambridge University Press, 1996.
3. M. Artin : Algebra, Prentice Hall of India, 1991.
4. N. Jacobson : Basic Algebra-I, HPC, 1984.
5. J.B.Fraleigh : A first couses in Algebra, 3rd edition, Narosa 1996.

2. CLASSICAL MECHANICS

Generalized coordinates, the Principle of least action, Galileo's relativity principle, the Legrangian for a free particle, Legrangian for a system of particle, energy, momentum, centre of mass, angular momentum, motion in one dimension, determination of the potential energy from the period of oscillation, the reduced mass, motion in a central field.

Free oscillation in one dimension, angular velocity, the inertia tensor, angular momentum of a rigid body, the equation of motion of a rigid body, Eulerian angle, Euler's equation.

The Hamilton's equation, the Routhian, Poisson brackets, the action as a function of the co ordinates, Maupertui's principle.

The Canonical transformation, Liouville's theorem, the Hamiltonian – Jacobi equation, separation of the variables, adiabatic invariants, canonical Variables.

TEXT BOOKS

1. L. D. Landau and E. M. Lifshitz - MECHANICS, (Third Edition) (Butter worth – Heinenann)

REFERENCE BOOKS

1. M. G. Calkin, Lagrangian and Hamiltonian Mechanics, Allied
2. Herbert Goldstein, Classical mechanics, Narosa
3. K C Gupta, Classical mechanics of particles and Rigid Bodies, Wiley Eastern

3. NUMBER THEORY

Multiplicative and completely multiplicative functions. Euler Toteint function. Möbius and Mangoldt function. Dirichlet product and the group of arithmetical function. Generalised convolution. Formal power series. Bell series.

Residue Classes and complete Residue Classes, Linear Congruences an Euler-Fermat Theorem, General Polynomial congruences and Lagrange Theorem, Wilson's Theorem, Chinese Reminder Theorem. Fundamental Theorem on Polynomial Congruences with prime power moduli. Quadratic Residue and Gauss's Law of Quadratic Reciprocity. (both for Legendre and Jacobi symbols) Primitive roots and their existence for moduli m=1, 2, 4, pα, 2pα.

Partition: partition of a +ve integer, Graphical representation, Conjugate, Generating functions, A theorem of Jacobi, Theorem 353 and 354, Applications of theorem 353. Congruence properties of P(n), Two theorems of Euler, Rogers – Ramanujan Identities (portion to be covered as per Chapter-XIX of "An Introduction to the Theory of Numbers" written by G. H. Hardy and E. M. Wright.).

TEXT BOOKS

1. T. M. Apostol: Introduction to Analytical number theory, Oxford University Press, 2000.
2. G. H. Hardy and E. M. Wright: An introduction to the Theory of Numbers, Oxford University Press, 1996.
3. Thomas Keshy: Elementary Number Theory with Applications Acad. Press, 2005.

REFERENCE BOOKS

1. I. Niven and H. S. Zuckerman: An introduction to the Theory of Numbers, John Wiley, 2002.
2. J. V. Uspensky and M. A. Heaslott: Elementary Number Theory, Mc Graw-Hill 1996.

4. MATHEMATICAL MODELING

Meaning of first and second order ordinary derivatives – slope of a tangent and curvature. Connecting these concepts to practical observation.

Basic concepts. Real world problems, (Physics, Chemistry, Biology, Economics, and others) Approximation of the problem, Steps involved in modeling.

Microbial population models – Single species nonage-structured population models – age structured population models – two species population models – multispecies population models – optimal exploitation models – epidemic models – models in genetics – mathematical models in pharmacokinetics – models for blood flows – models for other biofluids – diffusion and diffusion reaction models – optimization models in biology and medicine.

TEXT BOOKS

1. J. N. Kapur : Mathematical Moodelling, Wiley Eastern Ltd., 1998.
2. W.J.Meyer, Concepts of Mathematical Modelling, McGraw Hill, Tokyo, 1985.

REFERENCE BOOKS

1. Neil Gerschenfeld : The nature of Mathematical modeling, Cambridge Univeristy Press, 1999.
2. A. C. Fowler : Mathematical Models in Applied Sciences, Cambridge Univeristy Press, 1997.

5. SPECIAL FUNCTIONS

Hypergeometric series: Definition- convergence- Solution of second order ordinary differential equation or Gauss equation- Confluent hypergeometric series- Binomial theo rem, Integral Representation- Gauss's Summation formula- Chu-Vandermonde Summation formula- Pfaff-Kummer Transformation Formula- Euler's transformation formula.

Basic-hypergeometric series: Definition- Convergence- q-binomial theorem- Heines transformation formula and its q-analogue- Jackson transformation formula- Jacobi's triple product identity and its applications - Quintuple product identity - Ramanujan's 1 ψ1 summation formula and its applications- A new identity for $(q;q)^{10}$ with an application to Ramanujan partition congruence modulo 11- Ramanujan theta-function identities involving Lambert series.

q−series and Theta-functions: Ramanujan's general theta-function and special cases- Entries 18, 21, 23, 24, 25, 27, 29, 30 and 31 of Ramanujan's Second note book (as in text book reference 4).

Partitions: Definition of partition of a +ve integer- Graphical representation- Conjugate- Self-conjugate- Generating function of p (n)- other generating functions- A theorem of Jacobi- Theorems 353 and 354- applications of theorem 353- Congruence properties of p (n)- p (5n + 4) ≡ 0 (mod 5) and p (7n + 4) ≡ 0 (mod 7)- Two theorems of Euler- Rogers-Ramanujan Identities- combinatorial proofs of Euler's identity, Euler's pentagonal number theorem. Franklin combinatorial proof. Restricted partitions- Gaussian. (portion to be covered as per Chapter-XIX of An Introduction to the Theory of Numbers written by G. H. Hardy and E. M. Wright).

TEXT BOOKS

1. C. Adiga, B. C. Berndt, S. Bhargava and G. N. Watson, Chapter 16 of Ramanujan's second notebook: Theta-function and q-series, Mem. Amer. Math. Soc., 53, No.315, Amer. Math. Soc., Providence, 1985.
2. T. M. Apostol: Introduction to Analytical number theory, Oxford University Press, 2000.
3. G. E. Andrews, The theory of Partition, Cambridge University Press, 1984
4. B. C. Berndt, Ramanujans notebooks, Part-III, Springer-Verlag, New York, 1991.
5. B. C. Berndt, Ramanujan's notebooks, Part-IV, Springer-Verlag, New York, 1994
6. B. C. Berndt, Ramanujans notebooks, Part-V, Springer-Verlag, New York, 1998
7. George Gasper and Mizan Rahman, Basic hyper-geometric series, Cambridge University Press, 1990.
8. G. H. Hardy and E. M. Wright, An Introduction of the Theory of Numbers, Oxford University Press, 1996.

REFERENCE BOOKS

1. B. C. Berndt, S. H. Chan, Zhi-Guo Liu, and Hamza Yesilyurt, A new identities for with an application to Ramanujan partition congruence modulo 11, Quart. J. Math. 55, 13-30, 2004.
2. M. S. Mahadeva Naika and H. S. Madhusudhan, Ramanujan's Theta-function identities involving Lambert Series, Adv. Stud. Contemp. Math., 8, No.1, 3-12, MR 2022031 (2004j: 33021), 2004.
3. M. S. Mahadeva Naika and K. Shivashankara, Ramanujan's. $1\Psi_1$ summation formula and related identities, Leonhard Paul Euler Tricentennial Birthday Anniversary Collection, J. App. Math. Stat., 11(7), pp. 130-137, 2007

4. Sarachai Kongsiriwong and Zhi-Guo Liu, Uniform proofs of q-series-product identity, Result. Math., 44(4), pp. 312-339, 2003.
5. Shaun Cooper, The Quintuple product identity, International Journal of Number Theory, Vol. 2(1), 115-161, 2006.

MA305E: Elective – II

1. FINITE DIFFERENCE METHODS

Ordinary Differential Equations: Multistep (Explicit and Implicit) Methods for Initial Value problems, Stability and convergence analysis, Linear and nonlinear boundary value problems, Quasilinearization. Shooting methods.

Finite Difference Methods : Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Cubic splines and their application for solving two point boundary value problems.

Partial Differential Equations: Finite difference approximations for partial derivatives and finite difference schemes for Parabolic equations : Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem. Hyperbolic Equations : Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods. Elliptic equations Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

TEXT BOOKS

1. M.K.Jain, Numerical Solution of Differential Equations, Wiley Eastern, Delhi, 1985.
2. G.D.Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, 2004.
3. M.K.Jain, S.R.K.Iyengar and R.K.Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2002.

2. DIFFERENTIAL GEOMETRY

Graphs and level sets of functions on Euclidean spaces, vector fields, integral curves of vector fields, tangent spaces. Surfaces in Euclidean spaces, vector fields on surfaces, orientation, Gauss map. Geodesics, parallel transport, Weingarten map. Curvature of plane curves, arc length and line integrals. Curvature of surfaces. Parametrized surfaces, local equivalence of surfaces. Gauss-Bonnet Theorem, Poincare-HopfIndex Theorem**.**

TEXT BOOKS

1. M. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. B. O'Neill, Elementary Differential Geometry, Academic Press, New York,1966.
3. J.J. Stoker, Differential Geometry, Wiley-Interscience, 1969.
4. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer (India), 2004.

3. GRAPH THEORY

Connectivity :- Cut- vertex, Bridge, Blocks, Vertex-connectivity, Edge-connectivity and some external problems, Mengers Theorems, Properties of n-connected graphs with respect to vertices and edges.

Planarity:- Plane and Planar graphs, Euler Identity, Non planar graphs, Maximal planar graph Outer planar graphs, Maximal outer planar graphs, Characterization of planar graphs , Geometric dual, Crossing number.

Colorability :- Vertex Coloring, Color class, n-coloring, Chromatic index of a graph, Chromatic number of standard graphs, Bichromatic graphs, Colorings in critical graphs, Relation between chromatic number and clique number/independence number/maximum degree, Edge coloring, Edge chromatic number of standard graphs Coloring of a plane map, Four color problem, Five color theorem, Uniquely colorable graph. Chromatic polynomial.

Matchings and factorization:-Matching- perfect matching, augmenting paths, maximum matching, Hall's theorem for bipartite graphs, the personnel assignment problem, a matching algorithm for bipartite graphs, Factorizations, 1-factorization, 2-factorization. Partitions-degree sequence, Havel's and Hakimi algorithms and graphical related problems.

Directed Graphs:- Preliminaries of digraph, Oriented graph, indegree and outdegree, Elementary theorems in digraph, Types of digraph, Tournament, Cyclic and transitive tournament, Spanning path in a tournament, Tournament with a hamiltonian path, strongly connected tournaments.

Domination concepts and other variants:- Dominating sets in graphs, domination number of standard graphs, Minimal dominating set, Bounds of domination number in terms of size, order, degree, diameter, covering and independence number, Domatic number, domatic number of standard graphs

TEXT BOOKS

1. F. Harary: Graph Theory, Addison -Wesley,1969
2. G.Chartrand and Ping Zhang: Introduction to Graph Theory. McGrawHill, International edition (2005)
3. J.A.Bondy and V.S.R.Murthy: Graph Theory with Applications, Macmillan, London, (2004).

REFERENCE BOOKS

1. D.B.West, Introduction to Graph Theory,Pearson Education Asia, 2nd Edition, 2002.
2. Charatrand and L. Lesnaik-Foster: Graph and Digraphs, CRC Press (Third Edition), 2010.
3. T.W. Haynes, S.T. Hedetneime and P. J. Slater: Fundamental of domination in graphs, Marcel Dekker. Inc. New York.1998.
4. J. Gross and J. Yellen: Graph Theory and its application, CRC Press LLC, Boca Raton, Florida, 2000.
5. Norman Biggs: Algebraic Graph Theory, Cambridge University Press (2nd Ed.)1996.
6. Godsil and Royle: Algebraic Graph Theory: Springer Verlag, 2002.
7. N. Deo: Graph Theory: Prentice Hall of India Pvt. Ltd. New Delhi – 1990.

4. DESIGN & ANALYSIS OF ALGORITHMS

Introduction : Concepts in algorithms analysis (best case, average case and worst case complexity calculations), asymptotic complexity of the algorithms in Basic search and traversal techniques : General techniques, code optimization, Graphs and trees, Biconnected graphs, DFS, BFS,Kruskal, Prims and Dijkstra algorithms.

Domain independent algorithms and design techniques : Divide and conquer, greedy method.

Dynamic Programming, Back tracking. Branch and Bound Technique.

Algebraic simplification and transformation, the general method, evaluation and interpolation, the fast Fourier transform, modular arithmetic.

Lower bound theory : Comparison trees, Oracles and adversary arguments, techniques for algebraic problems, lower bounds on parallel computation.

NP-hard problems and NP-complete problems: Nondeterministic algorithms, Cook's theorem, NP-hard graph problems, NP-hard scheduling problems, NP-hard code generation problems.

Approximation algorithms for NP-hard problems: Absolute approximations, epsilon approximations, polynomial and fully polynomial time approximation schemes, and probabilistically good algorithms.

TEXT BOOKS

1. Horowitz and Sahni, Fundamentals of Computer Algorithms, Computer Science Press, Maryland, 2006.
2. Aho, Hopcroft and Ullman, The design and analysis of algorithms, Addison-Wisley, London, 1974.
3. T. Cormen, C. Leiserson, R. Rivest and C. Stein, Introduction to Algorithms, MIT Press, 2001.

REFERENCE BOOKS

1. Baase S and Gelder, A.V, computer Algorithms, Addition- Wesle Langman Singapore, Ptv. Ltd. India, 2000.
2. Garey, M.R, and Johnson, D.S, Computers and Intractability: A Guide to the Theory of NP-Completeness, W. H. Freeman, San Francisco,1976.
3. R. Sedgewick, Algorithms in C++, Addison- Wesley, 1992.
4. David Harel, Algorithms, The spirit of Computing, Addison-Wesley, Langman, Singapore, Pvt.Ltd.India, 2000.

5. CONTINUUM MECHANICS

TENSORS: Summation Convention – Components of a tensor – Transpose of a tensor – Symmetric & anti-symmetric tensor – Principal values and directions – Scalar invariants.

KINEMATICS OF A CONTINUUM: Material and Spatial descriptions – Material derivative – Deformation – Principal Strain – Rate of deformation – Conservation of mass – Compatibility conditions.

STRESS: Stress vector and tensor – Components of a stress tensor – Symmetry – Principal Stresses – Equations of motion – Boundary conditions.

LINEAR ELASTIC SOLID: Isotropic solid – Equations of infinitesimal theory – Examples of elastodynamics elastostatics.

NEWTONIAN VISCOUS FLUID: Equations of hydrostatics – Newtonian fluid – Boundary conditions – Stream lines Examples of laminar flows – Vorticity vector – Irrotational flow.

TEXT BOOKS

1. Lai W.M., Rubin D. and Krempel E., “Introduction to Continuum Mechanics”, Pergamon Unified Engineering Series, 1974.

REFERENCES

1. Hunter S.C., “Mechanics of Continuous Media”, Ellis Harwood Series, 1983.
2. Chung T.J., “Continuum Mechanic”, Prentice Hall, 1988. 3. Chandrasekaraiah D.S. and Loknath D

MA403E: Elective – III

1. FINITE ELEMENT METHOD

Finite Element Method : Variational formulation – Rayleigh-Ritz minimization – weighted residuals – Galerkin method applied to boundary value problems.

Global and local ¹nite element models in one dimension – derivation of ¹nite element equation.

Finite element interpolation – polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements – global interpolation functions.

Local and global forms of ¹nite element equations – boundary conditions – methods of solution for a steady state problem – Newton-Raphson continuation – one dimensional heat and wave equations.

TEXT BOOKS

1. J.N.Reddy, An introduction to the Finite Element Method, McGraw Hill, NY, 2005.
2. I.J. Chung, Finite element analysis in Fluid Dynamics, McGraw Hill Inc., 1978.

REFERENCE BOOKS

1. O.C. Zienkiewiez and K. Morgan : Finite Elements and approximation, John Wieley, 1983
2. P.E. Lewis and J.P. Ward : The Finite element method- Principles and applications, Addison Weley, 1991.
3. L.J. Segerlind: Applied finite element analysis (2nd Edition), John Wiley, 1984

2. COMPUTATIONAL FLUID DYNAMICS

Basic Equations of Fluid Dynamics: Continuity equation; Momentum equation; Energy equation ; Main Non-dimensional groups- Reynolds number, Froude number, Prandtl number, Mach number, Speci¹c heat ratio etc.; Equations expressed in conservative form. Inviscid Flows. Incompressible potential flows; Flows due to Sources and Sinks; Inverse method-I Von Karman's method for approximating flow past bodies of revolution; Inverse method-II : Conformal mapping; Panel method; Elliptic equations - Potential flows in ducts or around bodies –Circular cylinder inside a channel; Propagation of a finite amplitude wave and formation of a shock-Method of characteristics.

Viscous fluid flows: Governing equations for viscous flows; Structure of a plane shock wave; self similar laminar Boundary layer flows; flat plate thermometer problem; Ordinary boundary

value problems involving derivative boundary conditions- pipe and open channel flows; Explicit method for solving generalized Rayleigh problem; Implicit method for solving starting flows in a channel problem; Numerical solution of a bi-harmonic equations- Stokes flows.

TEXT BOOKS

1. Chuen-Yen-Chow and Sedat Biringen, An introduction to computational Fluid Mechanics, Wiley, 2011.
2. Tarit Kumar Bose, Computational Fluid Dynamics, Wiley Eastern Ltd., 1988.
3. C.A.J. Fletcher, Computational Techniques for fluid Dynamics Vol.II , Springer-Verlag, Berlin, 1991.

3. ADVANCED OPERATIONS RESEARCH

Nonlinear programming problem: Constrained NLPP, Lagrange's multipliers method – convex NLPP, Kuhn - Tucker conditions (including the proof) – Quadratic programming (Wolfe's and Beale's methods)

Network analysis: Preliminaries – min cost flow problem – max flow problem – CPM/PERT. Scheduling and sequencing.

Geometric Programming.

Integer Programming: Gomory's cutting plane method for an integer linear programming problem and a mixed integer linear programming problem – Assignment problem – travelling salesman problem.

Dynamic programming: Multistage decision process – concept of sub optimization – principle of optimality – computational procedure in dynamic programming -Application to problems involving discrete variables, continuous variables and constraints involving equations and inequations – application to linear programming problem.

TEXT BOOKS:

1. H.A.Taha , Operations Research, An Introduction, PHI, 2008
2. Kambo, Mathematical Progamming Techniques, East-West Pub., Delhi, 1991
3. Kanti Swarup et. al., Operations Research, Sultan Chand and Co., 2006
4. J.C.Pant, Introuduction to Operations Research, Jain Brothers, 2008.

4. THEORY OF AUTOMATA

Preliminaries: Sets, Relations, Equivalence relation, partition, Transitive closures, Kleene' closure *, Strings, Alphabets, Languages, Recursive definitions.

Regular Languages and Finite Automata: Regular Expressions, Regular Languages, Finite State Machines, Deterministic finite automata (DFA), Non-deterministic finite automata (NFA), Nondeterministic finite automata with e moves (NFA-e), e-closure, Equivalence of DFA, NFA and NFA-e, Language accepted by Finite Automata, Kleene's Theorem.

Properties of Regular Sets: Properties of the Languages accepted by finite automata, Regular and non-regular languages, Minimal finite automata, Pumping lemma, Myhill – Nerode theorem. Closure properties of Regular languages,

Context Free Languages and Pushdown Automata: Context free grammars (CFG), context free languages (CFL), closure properties of context free languages, Chomsky normal form, Greibach normal form, Pumping lemma for CFL, parsing, Pushdown automata (PDA), CFG for PDA, PDA for CFG, phrase structured grammars and languages and context sensitive grammars and languages.

Turing Machines: Turing machine model, example, Modification of Turing machines, Church's hypothesis and Non-deterministic Turing machines.

TEXT BOOKS

1. Hopcroft J. and Ullman J.D., Introduction to Automata Theory, languages and computation, Narosa Publishing, 1989.
2. Martin, J.C., Introduction to Languages and the theory of computation,Tata McGraw Hill, 2009.
3. Carrel J. and Long D., Theory of ¹nite automata with an introduction to formal languages, Prentice Hall, 1989.

5. RIEMANNIAN GEOMETRY

Differentiable manifolds:- Charts, Atlases, Differentiable structures, Topology induced by differentiable structures, equivalent atlases, complete atlases. Manifolds. Examples of manifolds. Properties of induced topology on manifolds.

Tangent and cotangent spaces to a manifold. Vector fields. Lie bracket of vector fields. Smooth maps and diffeomorphism. Derivative(Jacobi) of smooth maps and their matrix representation. Pull back functions.

Tensor fields and their components. Transformation formula for components of tensors. Operations on tensors. Contraction, Covariant derivatives of tensor fields.

Riemannian Metric. Connections. Riemannian connections and their components, Parallel translation, Fundamental theorem of Riemannian Geometry. Curvature and torsion tensors. Bianchi identities, Curvature tensor of second kind. Sectional curvature. Space of constant curvature. Schur's theorem.

Curves and geodesics in Riemannian manifold. Geodesic curvature, Frenet formula.

Hypersurfaces of Riemannian manifolds Gauss formula, Gauss equation, Codazzi equation, Sectional curvature for a hyper surface of a Riemannian manifold, Gauss map, Weingartan map and Fundamental forms on hypersurface. Equations of Gauss and Codazzi. Gauss theorem egregium.

TEXT BOOKS

1. Y. Matsushima : Differentiable manifolds. Marcel Dekker Inc. New, York,1972.
2. W.M .Boothby : An introduction to differentiable manifolds and Riemannian Geometry.Academic Press Inc. New York, 1975.
3. N.J. Hicks : Notes on differential Geometry D.Van Nostrand company Inc. Princeton, New Jersey, New York, London (Affiliated East-West Press Pvt.
Ltd. New Delhi), 1998.

REFERENCE BOOKS

1. R.L. Bishop and Grittendo : Geometry of manifolds. Acamedic Press, New York, 1964.
2. L.P. Eisenhart : Riemannian Geometry. Princeton University Press, Princetion, New Jersey, 1949.
3. H. Flanders : Differential forms with applications to the physical science, Academic Press, New York, 1963.
4. R.L. Bishop and S.J. Goldberg : Tensor analysis on manifolds, Macmillan Co., 1968.
5. K. S. Amur, D.J. Shetty and C. S. Bagewadi, An introduction to differential Geometry, Narosa Pub. New Dehli, 2010.

MA404E: Elective – IV

1. CALCULUS OF VARIATIONS & INTEGRAL EQUATIONS

Introduction to Calculus of Variations. Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

TEXT BOOKS:

1. A.S. Gupta.. Calculus of Variation, Prentice Hall of India Pvt. Ltd.
2. I.M.Gelfand and S. V. Francis.. Calculus of Variation, Prentice Hall, New Jersey.
3. L. G. Chambers.. Integral Equations, International Text Book Company Ltd., London.
4. F. G. Tricomi.. Integral equations, Interscience, New York.

2. CRYPTOGRAPHY

Basic number theoretic & Algebraic concepts – Time Estimates of doing arithmetic, Divisibility, Euclidean & Extended Euclidean Algorithm, Congruences, Chinese Remainder Theorem, Euler's & Fermat's theorems, Finite ¹elds, Quadratic Residues and reciprocity;

Classical Cryptography – some simple cryptosystems and their cryptanalysis; Secret Key Cryptosystems – Block ciphers, DES & AES; Hash Functions; Stream ciphers;

Public Key Cryptosystems – RSA Cryptosystem, Primality testing, Factoring algorithms; Rabin Cryptosystem; Di·e-Hellman Keyexchange protocol; Discrete-log problem; ElGamal Cryptosystems;

Elliptic curves – basic facts; elliptic-curve cryptosystem; Digital Signature schemes; Zero-knowledge protocols, one-way functions; Advanced protocols for different applications, e.g. e-cheque, ecash etc.; Copyright protection; Current trends in Cryptography;

TEXT BOOKS

1. Douglas R. Stinson, Cryptography: Theory and Practice, Chapman & Hall/CRC, 3 Edition, 2006
2. Neal Koblitz, A Course in Number Theory and Cryptography, Springer, 1994
3. Bruce Schneier, Applied Cryptography: Protocols, Algorithms and Source Code In C, John Wiley, 2002.
4. Ranjan Bose, "Information Theory, Coding and Cryptography", Tata McGraw-Hill Publishing, 2002

3. OBJECT ORIENTED PROGRAMMING

Basic concepts of object oriented programming – Benefits of oops- Object oriented languages – Applications of oops.

Structure of C++ program- Tokens, Expressions and Operators- Functions in C++-Function overloading – Friend and virtual Functions.

Classes and Objects-C++ Program with class-Nesting of member functions-private member functions-Arrays within a classmemory allocation for objects-Static data members-Arrays of objects-objects as Function arguments-Friendly functions, Returning objects.

Constructors and Destructors- Multiple constructors in a class - Constructors with default arguments-copy constructor-Dynamic constructors.

Operator overloading-overloading unary operators-overloading binary operators-overloading binary operators using Friends- Rules for overloading operators – Type conversions

Inheritance-Defining derived classes-Single inheritance-multilevel inheritance-Multiple inheritance-Hierarchical inheritance-Virtual base classes – Abstract classes. Pointers, Virtual functions and Polymorphism.

TEXT BOOKS

1. Balaguruswamy, Object oriented programming with C++, 4 Edition, Tata McGraw Hill, 2008.
2. Barkakati Nabajyoti, Object-Oriented programming in C++, PHI,1991.
3. Stroustroup Bjarne. The C++ Programming Language, 2 Edition, Addison-Wesley,1991.

4. FINANCIAL MATHEMATICS

Basic concepts of hedging and pricing by arbitrage in discrete time models, Setting of binomial tree models. Concepts of conditional expectation, martingale, change of measure, and representation. Mathematical models for the development and analysis of continuous time models. Brownian motion, stochastic calculus, change of measure, martingale representation theorem. Black-Scholes option pricing formula. Models for the interest rate in the national and international markets. Mathematical models of bond and stock prices, other derivative securities; Markowitz portfolio optimization theory and the Capital Asset Pricing Model; and interest rates and their term structures. Case studies,

TEXT BOOKS

1. RJ Williams, Introduction to Mathematics of Finance, AMS, 2006
2. Marek Capiński, Tomasz Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer, 2003

5. ALGEBRAIC TOPOLOGY

Paths and homotopy, homotopy equivalence,contractibility, deformation retracts.

Basic constructions: cones, mapping cones,mapping cylinders, suspension. Cell complexes, subcomplexes, CW pairs. Fundamental groups. Examples (including the fundamental group of the circle) and applications (including Fundamental Theorem of Algebra, Brouwer Fixed Point Theorem and Borsuk-Ulam Theorem, both in dimension two). Van Kampen's Theorem,
Covering spaces, lifting properties, deck transformations. universal coverings (existence theorem optional).

Simplicial complexes, barycentric subdivision, stars and links, simplicial approximation. Simplicial Homology. Singular Homology. Mayer-Vietoris Sequences. Long exact sequence of pairs and triples. Homotopy invariance and excision (without proof).

Degree. Cellular Homology. Applications of homology: Jordan-Brouwer separation theorem, Invariance of dimension, Hopf's Theorem for commutative division algebras with identity, Borsuk-Ulam Theorem, Lefschetz Fixed Point Theorem.

Optional Topics:
Outline of the theory of: cohomology groups, cup products, Kunneth formulas, Poincare duality.

TEXT BOOKS/ REFERENCE BOOKS

1. M. J. Greenberg and J. R. Harper, Algebraic Topology, Benjamin, 1981.
2. W. Fulton, Algebraic topology: A First Course, Springer-Verlag, 1995.
3. A. Hatcher, Algebraic Topology, Cambridge Univ. Press, Cambridge, 2002.
4. W. Massey, A Basic Course in Algebraic Topology, Springer-Verlag, Berlin, 1991.
5. J.R. Munkres, Elements of Algebraic Topology, Addison Wesley, 1984.
6. J.J. Rotman, An Introduction to Algebraic Topology, Springer (India), 2004.
7. H. Seifert and W. Threlfall, A Textbook of Topology, translated by M. A. Goldman, Academic Press, 1980.
8. J.W. Vick, Homology Theory, Springer-Verlag, 1994.