"अंतरी पेरू ज्ञानज्योत"

NORTH MAHARASHTRA UNIVERSITY,
JALGAON - 425 001

Syllabus
FOR M.Sc.(Computational Mathematics)
with effect from July 1994

DEPARTMENT OF MATHEMATICAL SCIENCES

M.Sc.(Computational Mathematics)

STRUCTURE

SEMESTER-I

MT-101	Calculus and Complex Analysis
MT-102	Topology
MT-103	Discrete Mathematical Structures
MT-104	Applied Abstract Algebra
MT-105	Computer Programming and Utilisation

SEMESTER-II

MT-201	Measure and Integration
MT-202	Mathematical Methods With Applications
MT-203	Functional Analysis
MT-204	Linear Algebra
MT-205	Computer Oriented Numerical Methods

SEMESTER-III

MT-301	Partial Differential Equations
MT-302	Advanced Analysis
MT-303	Optimization Techniques-I
MT-304	Advanced Topics on Lattice and Graph Theory
MT-305	Advanced Numerical Analysis

SEMESTER-IV

MT-401	Fluid Dynamics
MT-402	Operator Theory
MT-403	Optimization Techniques-II
MT-404	Special Functions
MT-405	Approximation Theory

M.Sc.(Computational Mathematics)

Detailed Syllabus

MT - 101 : CALCULUS AND COMPLEX ANALYSIS

1. Functions of several Variables: Linear transformations of the Euclidean n - space. Differentiability of functions of several variables. The chain rule. Contraction principle. Partial & directional derivatives. Inverse & Implicit function Theorems.

2. Uniform convergence of sequences and series of functions. Weirstrass M-test, power series, radius of convergence.

3. Analytic functions, Power series, expansion of analytic function. Fundamental Theorem of algebra Liouville's theorem. Cauchy's Theorem.

4. Singularities, Classification of singularities, poles and essential singularities. Singular part in Laurent series development. Rouche's Theorem.

5. Calculus of Residues.

Books Recommended

1. W. Rudin : "Principles of Mathematical Analysis" (Mc Graw. Hill International Student 3rd Ed.)
2. J.B. Conway : Functions of one complex Variables. (Springer - Verlag, Graduate text).
3. J.V. Deshpande: Complex Analysis, TMH, New Delhi.

MT - 102 : TOPOLOGY

1. Topological spaces: Defination & examples of topological spaces, Bases & sub bases. Subspaces, closed sets & closure. Neighbourhoods. Interior & accumulation points. Continuity & related concepts.

2. Spaces with special properties: Compactness. Lindeloff spaces, separable spaces, First and second countable spaces. Connectedness.

3. Separation Axioms:T_0, T_1 spaces, Hausdorff, Regular, Completely regular & normal spaces Compactness & separation axioms, Uryshon lemma

4. Product Topology:Product properties Tychnoff Theorem.

5. Local Compactness :Alexandroff's one point compactification

6. Complete Metric spaces:Baire category Theorem, contraction & fixed point. Completion of a metric space.

Books Recommended

1. K.D. Joshi : Introduction to general Topology. (Wiley Eastern Ltd. 1989).
2. J.R. Munkers : Topology a first Course. (Prentice Hall of India Pvt. Ltd.)
3. G.F. Simmons : Introduction to Topology & Modern Analysis. (Intenational Students Ed.)
4. J.L. Kelley : General Topology (Van Nostrand, princeton)
5. S. Willard : General Topology. (Addison Wesly Publising Com.)

MT – 103 : DISCRETE MATHEMATICAL STRUCTURE

1. Ordered Sets

Posets, Lattice as a poset & as an Algebra, semi-lattices,Representations of finite posets by covering relations, Chain, Conditions, isomorphism, isotone map, homomorphisms, sublattices, ideals, prime ideals, congurence relations, homomorphism theorems, complementation pseudocomplemented, meet semi-lattices, distributive modular lattices, with status of Characterizations, stone's Theorm & consequences.

2. Graph Theory

Graphs subgraphs, isomorphism, connected graphs, Euler graph, Hamiltonian paths and circuits travelling sales man problem:Trees & their properties, counting trees, spanning trees.

3. Combinatorics :

Basic combinatorial numbers, number of partitions of an integer, Algebra of formal power series, Generating functions. Recurrence Relation, Multinomials Sieve formula.

Books Recommended

1. Deo Narsingh : Graph Theory, (PHI 1987)
2. G. Gratzer : Lattice Theory . First Concepts & distributive lattices
3. G. Gratzer : General Lattice Theory (Academic Press 1978)
4. V. Krishnamurthy: Combinatorics (East West Press) 1989.
5. K.D. Joshi . Foundations of discrete Mathematics (Wiley Estern Ltd. 1989)
6. Prof. Mrs. N.S. Bhave & Prof. Raghunathan T.T. : Elements of Graph Theory (GAAJ Prakashan) 1990.
7. Deorr & Kenneth Leavesear : Applied Discrete structures for Computer Science. (Galoolia Publication Pvt. Ltd. 1988).
8. Frank Harary : Graph Theory, Narosa Publishing House 1989

MT – 104 : APPLIED ABSTRACT ALGEBRA

1. Rings & Ideals
   Introduction, Integral Domains and fields. Rings, Subrings, Ideals and quotient rings. Euclidean domains. Unique factorization theorem, polynomials.

2. Finite fields
   Extensions of fields, Irreducible polynomials over finite fields, factorization of polynomials over finite fields. Algebric Extensions.

3. Applications to Coding Theory.
   i) Binary Group Codes: Encoding and decoding. Block codes, Matrix encoding techniques, Group codes, Decoding tables, Hamming codes.
   ii) Polynomial codes;
   iii) Bose- choudhuri - Hocquenghem codes.
   iv) Radar communications systems. Difference codes, and its applications.

Books Recommended

1. Rudolf Lidl and Gunter Pilz (Springer Verlag. (19.4)) : Applied Asbtract Algebra and
2. G. Birkhoff and Thoms C. Barteepubl. Ad. Delhi.) 1987. : Modern Applied Algebra (CBS
3. N.H. McCoy Allyn and Bacon (1960). : Introduction to Modern Algebra
4. Berlekamp E.R. Hill, 1968. : Algebraic Coding Theory. McGraw

MT - 105 : COMPUTER PROGRAMMING & UTILISATION

1. Logical organization of computer system, introduction to number systems, introduction to computer programming. Algorithms & flow charts, program development process.

2. Introduction to FORTRAN-77. Character set, data types, expressions, operations, standard functions.

3. Sequential Structures :
   - Assignment Statement
   - Input & output statements (list-directed)
   - STOP Statement
   - END Statement

4. Selective Structures
   - GØTØ Statements : Assigned GØTØ, Computed GØTØ,
   - IF Statements : Logical IF, Block IF, Arithmatic IF,
   - Nested block IF structures
   - Multi - alternative selective structure

5. Repetitive Structures :
   - IF Loop
   - DO Loop
   - Nested DO Loop

6. Subscripted variables : Notation
   - Arrays
   - DIMENSION Statement
   - Input/Output of arrays
   - PARAMETER Statement

7. Format - Directed Input & Output
   - Input/Output Statements
   - FORMAT Statement
   - Format Specifications

8. Subprograms
   - Purpose & use
   - Functions : Library, Statement, Function subporgrous
   - Subroutine : CALL statement
   - DATA, SAVE, COMMON Statements,

9. File processing
   - Opening & closing files
   - Obtaining information about a file
   - File input & output
   - File positioning

10. Additonal features
    - PROGRAM Statement
    - PAUSE Statement
    - EQUIVALENCE Statement

Utilization

Writing FORTRAN-77 programs for the following.

1. Finding largest/Smallest of given numbers using array & without array.
2. For arranging given numbers in Ascending/Descending order using array/without array.
3. Matrix Multiplication
4. To find Transpose of a given Matrix
5. Find Sin x using Taylor's series & compare the obtained value with the value obtained using standard function.
6. To accept any integer number & write it in reverse order. Also find sum of its digits.
7. Generte first 100 prime number starting form any prime no.
8. Find GCD of given numbers.

Books Recommended

1. V. Rajaraman, Computer programming in FORTRAN-77, PHI (1990)
2. Programming with FORTRAN-77, Ram Kumar, THM
3. Kernighan B.W. & Plughter P.J.: Elements of programming style, Mc Graw Hill, New Yark

MT - 201 : MEASURE AND INTEGRATION

Cantor set and Cantor-like sets and the Lebesgue function. Lebesgue outer measure, measurable sets, σ-algebra, regularity of measure, complete measure. Measurable function, Borel sets and Borel measurability.

Integration of non-negative functions of a real variable. Fatou's Lemma. Lebesgue monotone convergence theorem the general integral. Lebesgue's dominated convergence theorem. Comparison of Riemann and Lebesgue integrals.

The four Dini derivates, functions of bounded variation, positive, negative and total variation. A function of $b.v.$ is continuous $a.e.$ A function of $b.v.$ is differentiable $a.e.$ and the derivative is finite $a.e.$ Differentation, indefinite intergral. Absolutely continuous functions and fundamental theorem of Calculus. A function is absolutely continuous iff (a) it is $b.v.$ (b) it is continuous (c) Preserves sets of measure zero. L_p-spaces

Convergence in measure, convergence in mean of order p, almost uniform convergence, Egoriff's theorem, implictions among these.

Books Recommended

1. De Barra, G. (1981) : Measure Theory and Integration Wiley Eastern, New Delhi.rn, New Delhi.
2. Royden, H.L. (1988) : Real Analysis, Third Edition, Macmillan Publishing Co. New York.
3. Halmos, P.R. : Measure Theory, Narosa Publication, Bombay
4. Rudin W. : Real and Complex Analysis. Tata McGraw Hill, New Delhi-11.

MT : 202 - MATHEMATICAL METHODS WITH APPLICATIONS

1. **The Laplace transform:**
   The transform concept, Defination of the Laplace transform. Transforms of elementary functions. Transforming initial value problems, Sectionally continuous fundtions. Functions of exponential order. Functions of class A, Transforms of derivatives. Derivations of transforms, The gamma function, Periodic functions.

2. **The inverse Laplace transform:**
   Definition of an inverse transform. A step function. Inverse Laplace transforms of derivatives. Inverse Laplace transforms, Partial fractions method. Simple initial value problems., Special integral equations.

3. **Applications to Physics:**
   Vibration of spring, Undamped Vibrations, Resonance. Damped vibrations, Applications to mechanics.

4. **Applictions to differential equations:**
   Ordinary differential equations with constant coefficients. Ordinary differential equations with variable coefficient. Simultaneous Ordinary differential equations. Partial differential equations.

5. **Applications to integral and difference equations:**
   Integral equations, integral equations of convolution type, Abel's integral equation. Integro-differential equations. Difference equations. Differential difference equations.

6. Fourier transform

Fouries series, Fourie integral formula, Examples of fourier transform, Fourier sine transform and Fourier cosine transform. Inversion theorems for complex Fourier transforms, Fourier sine transform and Fourier cosine transform. The convolution theorem, Parseval's indentity for Fourier integral. Relationship between Fourier and Laplace transform. Applications of Fourier transforms in intitial and boundary value problems.

7. Calculus of Variations.

Functionals, Some Simple Variational Problems, Function Spaces, The Variation of a functional, A Necessary Condition for an Extremum, The Simplest Variational Problem, Euler's Equation, The Case of Several Variables, A Simple Variable End Point Problem, The Variational Derivative, Invariance of Euler's Equation.

8. Further Generalizations

The Fixed End Point Problem for n unknown functions, Variational Problems in Parametric Form, Functionals Depending on Higher Order Derivatives, Variational Problems with Subsidiary Conditions.

9. The General Variation of a functional

Derivation of the Basic Formula, End Points Lying on Two Given Curves or Surfaces Broken Extermals, The Weierstrass-Erdmann Conditions.

Books Recommended

1. A.R. Vashistha & R.K. Gupta. : Integral Transform.
2. Gelfand & Fomin : Calculus of Variations.

MT : 203 - FUNCTIONAL ANALYSIS:

1. Banach spaces: Definition and examples, Construction of new normed linear spaces, Convexity of the unit sphere of a normed linear space, Linear transformations, Finite dimensional normed linear spaces. The Hahn-Banach theorem. The natural embedding. The open Mapping Theorem. The closed graph theorem. Banach-Steinhauss theorem.

2. Hilberts space: Definition and examples. Schwarz's inequality. Projection theorem, Orthonormal sets. Bessels's inequality. Parseval indentity. Gram-schmidt

orthogonalisation process. The conjugate space H^*, Operators and their adjoints on a Hilbert Projection operators.

3. Finite dimensional spectral theory. The spectral theorem.

Books Recommended

1. B.V. Limaye : Functional Analysis, Wiley Eastern, Ltd. 1988.
2. G.F. Simmon : Introduction to Topology & Modern Analysis,(International Edition)

MT : 204 - LINEAR ALGEBRA

Modules. Submodules. R-homomorphism direct sum. Finitely generated modules. Free modules PID.

Structure theorem for finitely generated modules over a PID. Applications to linear algebra. Jordan and rational Canonical forms. Applications to group theory. Structure of f-g and finite abelian groups.

Bilinear forms. Symmetric Bilinear forms. Orthogonal sum, Alternate forms. Structure of alternate forms. Quadratic forms, diagonalisation of Symmetric bilinear form. Sylvester's theorem.

Orthogonal geometry: Hyperbolic planes.Witte's cancellation Theorem.

Books Recommended

1. S. Lange : Linear Algebra.
2. Fraleigh,J.B. : Linear Algebra.
3. Jacobson, N. : Basic Algebra I.

MT - 205 : COMPUTER ORIENTED NUMERICAL METHODS

In the following topics on numerical methods, students are expected to be able to write programs, subprograms or program segments as well as perform numerical calculations using electronic calculators and mathematical tables.

1. Iterative Method for solution of algebraic equations

Newton Raphson method, iteration method, method of false position, rate of convergence, comparision of these methods, choice of an iterative method and implementation.

2. Solution of Simultaneous equations.
Direct methods - Cramers rule, Gauss elimination method, pivotal condensation. iterative methods - Gauss Seidal method, Jacobi methods.

3. Interpolation :
Lagrange and Newtoon interpolation methods, Finite difference operators, interpolating polynomials using finite differences, difference tables- central, forward, backward.

4. Numerical Integration
Methods based on interpolation, methods based on undetermined coefficients, composite integration methods Trapezoidal and Simpsons rules, double integration (derivation applications and errors in the formulae, comparison of two formulae)

5. Numerical Differentiation
Methods based on interpolation, finite differences and undetermined coefficients.

6. Solution of differential equations.
Numerical methods-Euler's method, Backward Euler method, Single step methods- Taylor series method, Runge Kutta methods, Multistep methods, Stability analysis.

Books Recommended

1. M.K. Jain, SRK Iyengar, Scientific R.K. Jain. : Numerical Methods for % Eng. Computation(Wiley Eastern Ltd. 87).
2. E. Balaguruswamy : Computer Oriented Statistical & Numerical Methods, (Macmillan Publication Ltd.) 88.
3. S.S. Sastry. : Introductory Methods of Numerical Analysis. PHI 1992.
4. H.M.Antia, : Numerical Methods for Scientists & Engineers TMH, 1991.

PRACTICALS

1. Draw the flow-chart and write a programme to find the root of the equation F(x) Ø by Newton Raphson method.
2. Draw the flow-chart and write a programme to find the root of the equation F(x) = Ø by Iteration method.
3. Draw the flow-chart and write a programme to find the root of the equation F(x)=Ø by False position method.
4. Draw the flow-chart and write a programme to integrate the given function using Trapezoidal rule.
5. Draw the flow-chart and write a programme to integrate the given function using Simpson's 1 ' rule.

6. Draw the flow-chart and write a programme for fitting of a polynomial of degree n using Lagrange's interpolation formula.
7. Draw the flow-chart and write a programme to solve a given differential equation using Euler's simple and modified method.
8. Draw the flow-chart and write a programme to soleve a given differential equation using Runge Kutta method.
9. Draw the flow-chart and write a programme to solve a given set of simultaneous equations using Gauss elimination method.
10. Draw the flow-chart and write a programme to integrate the given set of simultaneous equation using Gauss Seidal elimination method.
11. Draw the flow-chart and write a programme to integrate the given function using Simpson's 3/8 rule.
12. Draw the flow-chart and write a programme for finding the inverse of a given matrix.

MT 301 : PARTIAL DIFFERENTIAL EQUATIONS

1. **Strum-Liouville theory.**
   Formulation of a problem, Orthogonality of eigenfunctions, Nondegeneracy of eigenvalues, Positivity of the eigen values, completeness of the eigen function, asymptotic behaviour of the eigenvalues and eigenfunctions.

2. **Bessel's functions.**
   Bessel's equation, the power series solution of Bessel's equations, integral representation of Bessel's functions, the second solution of Bessel's equation, zeroes of Bessel functions, asymptotic behaviour, Fourier Bessel series, spherical Bessel function.

3. **Legendre functions.**
   Legendre equation, Legendre polynomial, Series expansions, associated Legendre function.

4. **Linear second order partial differential equations.**
   Classification of second order partial differential equations, linear equation in two independent variables, method of reduction to normal form, linear second order p.d.e. in more than two independent variables, method of reduction to normal form, superposition & subtraction principle, method of separation of variables.

5. Laplace equation.

Solution in cartesian co-ordinates, solution in a rectangle, Laplacian in polar co-ordinates, separated solutions of Laplace equation, applications to boundary value problems, Uniqueness of solutions, exterior problem, Wedge domain, Neumann's problem, explicit representation by poisson s formula, Laplacian in spherical co-ordinates, separated solutions of Laplace equation in spherical co-ordinates, boundary value problem in a sphere, boundary value problem exterior to a sphere

6. Heat equation.

homogeneous boundary conditions on a slab, separated solutions with boundary conditions, solution of initial value probelm on a slab, asymptotic behaviour & relaxation time, uniqueness of solutions, inhomogenerous boundary conditions on a slab, statement of problem and five stage methods of solution in a rectangle, Heat flow in a cylinder, separated solution, intial value problem in a cylinder, initial value problems between two cylinders, heat flow in a sphere, spearatd solutions of heat equation in spherical co-ordinates.

7. Quasi-linear system.

Linearization of a reducible system of quasi-linear equations by Hodograph transformations.

Books Recommended

1. Prinsky: Partial differential equations and applications to boundary value problems.
2. P. Prasad: Partial differential equations.

MT - 302 : ADVANCED ANALYSIS

1. Harmonic functions
   - The Cauchy Riemann equations
   - The Poisson integral
   - The mean value property
   - Boundary behaviour of Poisson integrals
   - Representation theorems
2. The maximum modulus principle
   - The Schwarz lemma
   - The Phragmen Lindelof method
   - An interpolation theorem
   - A converse of the maximum modulus theorem

3. Approximation by rational function
   - Preparation
   - Runge's theorem
   - The Mittag Leffer theorem
   - Simply connected regions

4. Conformal mapping
   - Preservation of angles
   - Linear fractional transformations
   - Normal families
   - The Riemann mapping theorem

5. Zeros of holomorphic functions
   - Infinite products
   - The Weierstrass factorization theorem
   - An interpolation problem.
   - Jenesen's formula
   - The Müntz Szasz theorem

Books Recommended

1. Real and Complex Analysis, Third Edition, Walter Rudin, McGraw Hill International Editions.
2. Complex Analysis, Third Edition Lars V. Ahlfors, McGraw Hill International Editions.

MT 303 : OPTIMIZAITON TECHNIQUES -I

Linear Programming : Graphical procedures; redundant activities, surplus resources; simplex algorithms theory and method; dual of a problem and properties of dual; dual simplex procedure, revised simplex procedure.

Applications of linear programming ; transportation problem; assignment problem; maximum flow in a given network; shortest route problem; transshipment problem, Integer programming; Pure LIPP; Mixed integer programming problem; branch and bound method, f -cut.

Books Recommended

1. Hadley, G. : Non-Linear and dynamic programming
2. Taha. H.A. : perations Research an Introduction, McMillan Co.
3. Gauss. S.I. : Linear Programming
4. Taha. H.A. : Integer Programming
5. Wagner : Principles of Operations Research
6. Kambo. N.S. : Mathematical Programming Techniques East-West Press, New Delhi.

MT 304 : ADVANCED TOPICS ON LATTICE AND GRAPH THEORY

LATTICE THEORY

1. Distributive Lattices :
   Characterization theorems and Representation theorems, Congruence relations, Algebraic lattices, JID, MID, Distributive lattices with pseudocomplementation.
2. Congruences and Ideals :
   Distributive, Standard and Neutral elements and Ideals, Structure theorems.
3. Modular and Semimodular Lattices :
   Modular, Semimodular lattices, Introduction to Geometric and partition Lattices.

GRAPH THEORY

1. Cutsets and Cut Vertices
   Cutsets and its properties, Fundamental circuits and Cutsets, connectivity and separability.
2. Planer and Dual Graphs :
   Different representation of a planar of graphs, Geometric and combinatorial dual.
3. Matrix Representation of Graphs :
   Incidence, Circuit, Cutset, Path and Adjencency matrices.
4. Enumeration of Graphs :
   Types of Enumeration, Counting labelled trees and Unlabelled trees, Polya's counting theorem.
5. Directed Graphs :
   Types of Diagraphs, Diagraphs and Binary relations.

Books Recommended

1. Graph Theory (PHI 1987) : Deo Narsingh
2. General Lattice Theory, (Academic Press,1978) : G.Gratzer.

MT 305 ADVANCED NUMERICAL ANALYSIS

1. Singlestep methods.
   Implicit Runge-Kutta Methods, Gorechkoff methods, System of differential equations- Taylor Series Method, Runge Kutta Methods, Stability analysis.
2. Multistep Methods.
   Explicit multistep methods, Multistep methods based on differentiation, Predictor corrector methods.
3. Difference methods for parabolic partial differential equations.

4. Differnece methods for hyperbolic partial differential equations.
5. Difference methods for Elliptic partial differential equations.
6. Finite Elements methods
Weighted residual methods, Variational Methods.

Books Recommended

1. M.K. Jain :Numerical Solutions of differential equations.
2. J.D. Smith :Numerical Analysis.

MT - 401 : FLUID DYNAMICS

1. Basic concepts

Velocity of a fluid particle, stream lines and path lines, methods of Euler and Lagrange, Relation between local and individual time rates, vorticity and vortex line, velocity potential, Differentation following the fluid, Equation of continuity in Euler's and Lagrange's form, Equivalence of two forms of the equation of continuity. Equation of continuity in curvilinear, polar, spherical & cylindrical co-ordinates, symmetrical forms of the equation of continuity, Boundary surface, Equation of motion in Euler's form, conservative field of force, Equations of motion in Lagrange's form, Intrinsic energy, The energy equation, Equation of impulsive motion, physical interpritation of vorticity vector, Analysis of the most general displacement of a fluid element.

2. Special Methods.

Motion in two dimensions, Stream function in two dimensions, physical meaning of $\psi(x,y) - \psi(x_o,y_o)$, velocity derived from the stream function, velocity in polar co-ordinates, The stream function of a Uniform stream, complex potential, The circle theorem, two dimensional source and its complex potential, Doublet and its complex potential, three dimensional source and its velocity potential, Uniform streaming deduced from a combination of a source and sink, combination of sources and streams, Images in two dimensions.

i) Image of a source in a straight line
ii) Image of doublet in a striaght line
iii) Image of a source in a circle
iv) Image of a Doublet in a circle,

Stockes' current function ψ, speical forms of ψ:

i) Steady streaming parliel to OX
ii) A source m at Ø
iii) A Doublet μ at Ø
iv) Finite line source along the axis Butler's sphere theorem, Images in three dimensions.

i) Image of a source in a plane
ii) Image of a Doublet in a plane
iii) Image of a source in a sphere
iv) Image of a radial Doublet in a sphere.

General method for images in a plane, conformal representation, conformal transformation of a source and a doublet, theorem of Blasius, Flow and circulation, Irrotational motion, Kelvin's circulation theorem, Helmholtz's vorticity equations.

3. Motion of a circular cylinder, General motion of a cylinder in two dimensions, Boundary conditions for the current function, Motion of a circular cylinder in a uniform stream, circulation about a circular cylinder.

4. Elliptic cylinder
Elliptic co-ordinates, Joukowski, transformation, streaming past a fixed Elliptic Cylinder, Streaming past a fixed cylinder of any shape.

5. Liquid Waves
Most general expression of a Wave motion Harmotic waves, plane waves in three dimensions.

6. Applications of conformal representation
Conformal transformation, Analysis of Joukwski's transformation, construction of Joukowski Aero fail, Flow with circulation past a rectangular Aerofoil, Flow with circulation past an Aerofoil, Schwarz- christoffel transformation.

7. Viscocity
Motion of a viscous fluid, Navier-stokes' Equations of motion.

Books Recommended

1. Bansi Lal, : Elementary Hydrodynamics, Atma Ram & Sons, Delhi, 1.ol.
2. F. Choriton : Textbook of Fluid Dynamics.

MT - 402 : OPERATOR THEORY

1. Compact operators on Banach spaces:
   Compact Linear maps, Normal compact operators, spectrum of a compact operators.
2. Bounded operators and adjoints; Normal and self adjoint operators. Compact self adjoint operators.
3. Spectral Analysis of self adjoint operators orthogonal projections, Resolutions of the operator, spectral theorem for bounded self adjoint operators, properties of spectra, Numerical range and spectrum of it, spectral radius of a weighted shift.

Books Recommended

1. B.V. Limaye : Functional Analysis, Wiley Eastern Ltd. 1989.
2. P.R. Halmos : A Hilbert Space problem book, Springer Int. Stt. Ed. 1975.

MT - 403 : OPTIMIZATION TECHNIQUES - II

Kuhn- Tucker optimality conditions, Convex programming and duality. Unconstrained and transformation optimization techniques. Quadratic programming. Non-linear programming. Geometric Programming. Goal programming Elements of Dybnamic Programming.

Books Recommended

1. Kambo, N.S. : Mathematical Programming Techniques, East West Press, New Delhi,
2. Taha,H.A. : Operations Research : A Introduction, Memillan Pub. Co.

MT - 404 : SPECIAL FUNCTIONS

1. Infinite products:
   Definition, Necessary condition for convergence, Absolute convergence, uniform convergence.
2. Gamma and Beta Functions:A series for $\Gamma'(z)/\Gamma(z)$, Evaluation of $\Gamma(1)$. The Euler product for $\Gamma(z)$ The difference equation $\Gamma(Z+1) = z\,\Gamma(z)$ Beta function. The value of $\Gamma(z)\,\Gamma(1-z)$ Legender's Duplication formula, Gauss multiplication Theorem.

3. Hypergeometric Function. The function F(a,b,c;z). Evaluation of F(a,b;c;1). The contiguous function relations.

4. Generalized Hypergeometric functions.
The function ${}_pF_q$. The contiguous functions relations. Saalschutz, Whipple and Dixon's theorem.

5. Generating functions;
Generating functions of the form $G(2xt-t^2)$; $A(t)\exp\{xt/(1-t)\}$.

6. Orthogonal polynomials;
Orthogonality, Legendre, Hermite and Laguerne polynomials.

Books Recommended

1. E.D. Rainville : Special functions, Chelsea Pub. Co. New York, 1960.

2. L.C. Andrews : Special functions of Mathematics for Engineers, McGraw Hill, 1992.

MT - 405 : APPROXIMATION THEORY

1. Introduction
General existence and uniqueness of approximations.

2. Uniform approximation.
Weierstrass theorem and Bernstein polynoimal approximation.Jackson's theorems.Characterization of Best approximation,Approximation on a finite set of points computatonal methods.

3. Least square approximation, Approximation on an interval,The Jacobi polynomials. Approximation on a finite set of points Effectiveness as a uniform approximation.

4. Polynomial and spline interpolation
General results,
The size of Lebesgue consvant Interpolating polynomials as Least squares approximations. Interpolation and approximation by splines. Some extermal proprties of splines. Uniform approximation by splines Least square approximation by splines.

5. Approximation & interpolation by rational functions. Existence, characterization & uniqueness. Degree of approximation, Finite point sets, Rational interpolation, computing a Best Approximation.

6. Pade'approximations, Definition & proprties of Pade' approximation, Direct theorem for the rows of the Pade'-table. Converse theorem for the rows of the Pade' table.

Books Recommended

1. Theodore J.Rivlin : An introduction to the approximation theory naisdell Pub. Co.

2. P.P.Petrushev & V.A. Popov : Rational approximation of real functions, Cambridge Univ. Press.

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