UNIVERSITY OF PUNE

DEPARTMENT OF MATHEMATICS

SYLLABUS

M.Sc

A two years duration course with total 100 credit points

FIRST YEAR

SEMESTER I (All are compulsory and each course is of 5 credit points)

MT 101 Advanced Calculus
MT 102 Topology
MT 103 Measure and Integration
MT 104 Algebra
MT 105 Differential Equations

Total credits:25 points

SEMESTER II (All are compulsory and each course is of 5 credit points)

MT 201 Functional Analysis
MT 202 Complex Analysis
MT 203 Field Theory
MT 204 Linear Algebra
MT 205 Numerical Analysis.

Total credits: 25 points

SECOND YEAR

*(In each of **semester III** and **semester IV**, any five of the following courses which are running in the department should be opted)*

(each course is of 5 credit points)

MT 01. Operations Research
MT 02. Integral Transforms
MT 03. Number Theory
MT 04. Coding Theory
MT 05. Graph Theory
MT 06. Lattice Theory
MT 07. Computational Geometry
MT 08. Cryptography
MT 09. Financial Mathematics
MT 10. Modelling and Simulation
MT 11. Artificial Intelligence
MT 12. Symmetries
MT 13. Wavelets
MT 14. Combinatorics
MT 15. Partial Differential Equations
MT 16. Fuzzy Logic
MT 17. Statistics and Probability
MT 18. Fluid Dynamics
MT 19. Banach Algebra
MT 20. Boundary Value Problems
MT 21. Baer * Rings
MT 22.Topics in Matroid Theory
MT 23.Topics in Sperner Theory
MT 24.Differential Equation and Dynamical System
MT 25.Mechanics
MT 51. Complex Analysis II
MT 52. Representation Theory of Groups
MT 53. Fourier Analysis on Finite Groups
MT 54. Differential Geometry
MT 55. Non-Linear Dynamical System
MT 56. Emerging Technologies
MT 57. Algebraic Topology
MT 58. Analysis on Manifolds
MT 59. Projective Geometry
MT 60. Algebraic Geometry
MT 61. Algebraic Number Theory
MT 62. Algebraic Curves
MT 63. Commutative Algebra
MT 64. Advanced Topics in Lattice Theory

MT 65. Advanced Topics in Graph Theory
MT 66 Advanced Topics in Matroid Theory
MT 67. Advanced Topics in Group Theory
MT 68. Advanced Topics in Ring Theory
MT 69 Topics in Non Commutative Rings.

SEMESTER I

MT 101 Advanced Calculus

1. Compact and Connected Subsets of $R^{n.}$

2. Differentiation : Derivative, Continuously Differentiable functions, Chain rule, Inverse function theorem, Implicit function theorem.

3. Integration: integral over a rectangle, Existence of the Integral, evaluation of the integral, integral over a bounded set and rectifiable sets, improper integrals

4. Change of Variable Theorem (Proof of one variable) and Statement of n-variables (with Illustrations)

5. Line Integrals with Applications

Textbooks :

1. Analysis on Manifolds - J.R. Munkres : Sections 4 to 15 and Section 17.
2. Calculus (Volume II) - T.M. Apostol, Chapter 10 : Sections 10.1 to 10.9

MT 102 Topology

1. Cartesian Products, Finite Sets, Countable and Uncountable Sets, Infinite Sets and Axiom of Choice, Well Ordered Sets.

2. Topological Spaces : Basis for a topology, Order topology, Subspace Topology, Product topology, closed sets and limit points, Continuous functions, Metric

Topology

3. Connected spaces, Connected Subspaces of Real Line, Components and Local Connectedness, Compact spaces, Compact Subspaces of the Real Line, Limit point compactness, Local Compactness.

4. Countablity and Separation Axioms : Countability Axioms, Separation axioms Normal Spaces, Urysohn's Lemma, Titetz Extension Theorem (Without Proof), Tychonoff's Theorem , Metrization Theorem (without proof).

Textbook :

J. R Munkres : Topology : A First Course. (Prentice- Hall)

Chapter 1 : Sections 5,6,7,9,10
Chapter 2 : Sections 12 to 21
Chapter 3 : Sections 23 to 29
Chapter 4 : Sections 30 to 35
Chapter 5 : Section 37

MT 103 Measure and Integration

1. Preliminaries : Cardinal Numbers and Countability, Properties of Open Sets, Cantor Like Sets

2. Measure on Real Line : Lebesgue Outer Measure, Measurable Sets, Regularity, Measurable Functions, Borel and Lebesgue Measurability

3. Integration of Functions on Real Variable : Integration of Non Negative Functions, General Integral, Integration of Series, Riemann and Lebesgue Integral

4. Differentiation : Functions of Bounded Variation, Lebesgue Differentiation Theorem, Differentiation Theorem, Differentiation and Integration

5. Abstract Measure Spaces : Measures and Outer Measures, Extension of Measures, Uniqueness of Extension, Completion of Measure, Measure Spaces, Integration with respect to Measure

6. Inequaties and L^p spaces : The L^p Spaces, The Convex Functions, Jensen's Inequalities, Inequalities of Holder and Minkowski, Completion of L^p.

7. Convergence : Convergence in Measure, Almost Uniform Convergence, Convergence Diagrams, Counter Examples

Textbook :

Measure Theory and Integration : G. de Barra (New Age International Ltd, Publishers)

Chapter 1 : Sections 1.5 to 1.7.
Chapter 2 : Sections 2.1 to 2.5.
Chapter 3 : Sections 3.1 to 3.4.
Chapter 4 : Sections 4.1 to 4.5.
Chapter 5 : Sections 5.1 to 5.6.
Chapter 6 : Sections 6.1 to 6.5.
Chapter 7 : Sections 7.1 to 7.4.

MT - 104 Algebra

1. Introduction to Groups, Symmetries of a square, Dihedral Groups, Examples and properties of Groups, Finite Groups, Subgroups, Cyclic Groups.

2. Permutation Groups and its properties,check digit scheme Based on D_5, Isomorphisms, Cayley's Theorem, Cosets and Lagrange's Theorem,Applications of Cosets and Permutaion Groups, Rotation Group of a Cube and Soccer.

3. External Direct Products with Applications, Normal subgroups and Factor Groups and Applications.

4. Group Homomorphisms, First Isomorphism Theorem, Fundamental Theorem of Finite Abelian Groups.

5. Sylow Theorems, Applications of Sylow Theorems.

6. Introduction to Rings , Integral Domains, Fields, Ideals, Ring Homomorphisms, Polynomial Rings, Factorisation of Polynomials, Divisibilty in Integral Domains.

Text Book :

Contemporary Abstract Algebra (Fourth Edition)-Joseph Gallian (Narosa Publishing House).

Chapters: 1 to 18 and 24..

MT 105 Differential Equations

1. Linear equation of first order.

2. Applications : Orthogonal Trajectories, Population Growth and Decay, Newton's Law of Cooling, Free Falling Bodies

3. Linear equations with constant coefficients : Second order homogeneous

equations, initial value problems, linear dependence and independence, nonhomogeneous equations of nth order, Algebra of Constant Coefficients.

4. Applications : Simple Harmonic Motion, Damped Motion, Forced Motion, Other Applications in Electronics and Pendulum Problem

5. Linear equations with variable coefficients : Initial value problems, solutions of the homogeneous equation, Wronskian and linear independence, reduction of order nonhomogeneous equations Legendre equation.

6. Linear Equations with regular singular points : Euler equation, second order equation with regular singular points, exceptional cases, Bessel equation.

7. Existence and uniqueness of solutions to first order equations : Separation of variables, exact equations, Method of successive approximations, Lipschitz condition, Approximation to and uniqueness of solutions.

8. Existence and uniqueness of solutions to first order equations to systems and 2nd order equations

9. Laplace transforms: Laplace Transforms, Inverse Laplace Transform, Solving Initial Value Problems with Laplace Transforms.

Text Book :

1) E. A. Coddington : An Introduction to Ordinary Differential Equatins (Prentice-Hall).

Chapter 1 : Sections 1 to 7.
Chapter 2 : Sections 1 to 12.
Chapter 3 : Sections 1 to 8.
Chapter 4 : Sections 1 to 4, 7 and 8.
Chapter 5 : Sections 1 to 6.
Chapter 6 : Sections 6,7.

2) Differential Equations with Mathematica - Martha L. Abell and James P. Braselton (Second Edition) Acadamic Press..

SEMESTER II

MT 201 Functional Analysis

1. Normed spaces, continuity of linear maps, Hahn - Banach theorems, Banach spaces.

2. Uniform bounded principle, Application - Divergence of Fourier Series of Continuous Functions, closed graph theorem, Open mapping theorem, bounded inverse theorem, spectrum of Bounded Operator.

3. Duals and transposes, duals of $L^P[a,b]$ and C[a,b].

4. Inner product spaces, orthonormal sets, approximation and optimization, projections, Riesz representation theorem.

5. Bounded operators and adjoints on a Hibert space, normal, unitary and self adjoint operators.

6. Fourier Series and Integrals.

Textbook :
B.V. Limaye : Functional Analysis (Second Edition) - New Age International Limited..

Chapter 2 : Sections 5 to 8.
Chapter 3 : Sections 9 to 12.
Chapter 4 : Sections 13,14.
Chapter 6 : Sections 21 to 24.
Chapter 7 : Sections 25,26.
Chapter 1 : Section 4 (Fourier Series and Integrals).

MT 202 Complex Analysis

1. Complex number system: Complex plane, polar representation, lines and half planes, Spherical representation.

2. Analytic functions: Power series, analytic functions, Mobius transformations,

3. Applications of Conformal Mappings : Steady Temperatures, Steady Temperatures in a wall, Temperatures in a Quadrant with part of one Boundary Insulated, Electric Potential, Potential in a cylindrical space, Two Dimensional Fluid Flow, The stream Function, Flow around a Corner, Flow around a Cylinder

4. Integration: Power series representation of analytic functions Zeros of analytic function, Index of a closed curve, Cauchy's theorem, Homotopy Versions (without proof), simple Connectivity version (without proof), counting zeroes, Goursats theorem.

5. Singularities: Classification, residues, argument principle.

6. Maximum Modulus theorem: Maximum principle, Schwarz lemma.

Textbook

1. Complex Analysis - J.B. Conway (Second Edition) Narosa Publishing House..
Chapter 1 : Sections 1 to 6.
Chapter 3 : Sections 1 to 3.
Chapter 4 : Sections 2 to 8.
Chapter 5 : Sections 1 to 3.
Chapter 6 : Sections 1 to 2.

Textbook 2 : Complex Variables and Applications - Ruel V. Churchill (Second Edition)
Chapter 9..

MT 203 Field Theory

1. Fields - Example, Algebraic and Transcendental Elements, Degree of Field Extension, Construction with Ruler and Compass, Symbolic Adjunction of Roots, Finite Fields

2. The Main Theorem of Galois Theory - Cubic Equations, Summetric Functions, Primitive Elements, Proof of Main Theorem, Kummer Extension, Cyclotomic Extension, Quintic Extension.

Textbook :

Algebra - Michael Artin (Prentice Hall of India Private Limited).
Chapter 13 : Sections : 1 to 6.
Chapter 14 : Sections : 1 to 9.

MT 204 Linear Algebra

1. Modules : Definition and Examples, Further notions and Results

2. Free Modules : Linear Independence, Bases of Free Modules, Matrices and Homomorphisms

3. Vector Spaces : Definition and Examples, Subspaces, Bases and Dimensions, Linear Transformations, Quotient Spaces, Direct Sum, The matrix of Linear Transformation, Duality

4. Canonical Forms : Eigenvalues and Eigenvectors, The minimal Polynomial, Diagonalisability, Triangularisable Operators, Jordan Forms, The Rational Forms

5. Inner Product Spaces : Inner Product Spaces, Orthogonality, The Adjoint of Linear Transformation, Unitary operators, Self Adjoints and Normal Operators, Polar and

Singular Value Decomposition

6. Bilinear Forms : Definition and Examples, The matrix of a Bilinear Form, Orthogonality, Classification of Bilinear Forms

Textbook 1 : Modules - Luther and Passi (Narosa Publishing House). Chapters 1, 2.
Textbook 2 : Linear Algebra - Bisht and Sahai, Chapters 2 to 5.

MT 205 Numerical Analysis

1. Iterative solutions of nonlinear equation: bisection method. Fixed-point interation, Newton's method, secant method, acceleration of convergence, Newton's method for two non linear equations, polynomial equation methods.

2. Polynomial interpolation: interpolation polynomial, divided difference interpolation, Aitken's formula, finite difference formulas, Hermite's interpolation, double interpolation.

3. Linear systems of Equations: Gauss Elimination, Gauss-Jordan method, LU decomposition, iterative methods, and Gauss- Seidel iteration.

4. Numerical Calculus : Numerical differentiation, Errors in numerical differentiation, Numerical Integration, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, error estimates for Trapezoidal rule and Simpson's rule.

5. Numerical Solution of Ordinary differential Equations : Solution by Taylor series, Picard Method of successive approximations, Euler's Method, Modified Eular Method, Runge- Kutta Methods, Predicator-Corrector Methods.

6. Eigenvalue Problem : Power method, Jacobi method, Householder method.

7. Mupad Computer practicals.

Textbooks .
1. K.E. Atkinson : An Introduction to Numerical Analysis.
2. J. I. Buchaman and P. R. Turner : Numerical Methods and Analysis..
3. S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition) Prentice-Hall..

SECOND YEAR COURSES

MT 301 Theory of Computer Science and Database Fundamentals

1. **Lattices and Boolean Algebra** : Introduction, Hasse Diagram, Boolean Expressions, Boolean Identities, d.n.f., c.n.f., Logic Gates.

2. **Finite State Machines** - Introduction to Graphs, State Diagram, Transition Table, Finite State Automata, Deterministic and non-deterministic

3. **Formal Language** : Alphabets, Language, Grammar, Kleene Closure, Regular Expression, Finite Automata with output, Non deterministic automata, Moore Machines, Mealy Machines

4. **Turing Machine** - Tape Head Program, Deterministic, Non Deterministic, Accept, Reject, Loop

5. **Grammar and Languages** : Phase Structure Grammar, Types, Language Recognition, Regular Sets, Kleen's Theorem, Regular Grammar, Pumping Lemma Chomsky Hierarchy, Context Sensitive Grammar, Polish notation, Postfix, prefix, Grammars and Cohen Languages

6. **Introduction to DBMS** : File System Vs DBMS, Storing Data, Levels of abstraction, data independence, Structure of DBMS, Advantages of DBMS

7. **Conceptual Design** (ER Model) Additional constraints, weal entities, Aggregation, generalisation, conceptual design using ER, Entituy Vs relationship, binary Vs Ternary, Contraints beyond ER, Conceptual design for small to large enterprises, Case Studies,

8. **Relational data model** : Conversion of ER to Relational model, integrity constraints

9. **Relational algebra** : Preliminaries, Relational algebra

10. **Relational calculus** : Tuple calculus, Calculus Versus Relational Algebra

11. **SQL** : DDL, forms of a basic SQL query, union/ intersection/ except, nested queries, Aggregate Operators, Aggregate functions, Null Values, impact on SQL commands, outer joins, disallowing NULL, examles on SQL, Creating functions in PLSQL, cursors, triggers.

12. **Functional dependency** : Introductory to schema refinement, use of decomposition, problems relation to decomposition, functional dependencies, lossless-join decomposition, Normalisation and its forms.

Reference Books :

1. Applied Abstract Algebra - Lid and Pilz 2nd Edition
2. Introduction to Computer Theory by Colen

MT 302 Programming in C and C++

1. Introduction – Variables and Constants, Assignment Statements

2. Data Types – Integers, Floating Point Numbers, Void Data Type

3. Operators and Expressions – Operators, Assignment Operators, Precedence and Associativity

4. Control Statements – If Statements, Looping, Switch, Break, Continue Statements, Infinite Loops

5. Arrays and Pointers – Arrays, Initializing Arrays, Pointer Arithmetic, String Manipulations, Multidimensional Arrays, Pointers to Pointers, Dynamic Memory Allocation,

6. Structures and Unions – Structures and Functions, Array of Structures, Unions.

7. Files in C - File Operations, Command Line Arguments

8. Graphics in C - Concepts, Simple Programs

9. Preprocessor – Macro Substitution, Include Facility, Line Control

10. Types of Files – Logical File, Memory Hierarchy

12. File Organization – Fields and Record Organization, Overview of Indexes, Types.

13. Tree Structured Indexing – Sequential and Binary Searching, ISAM, B+ Tree Indexing, Static Hashing, Dynamic Hashing, Linear and Extendible Hashing

14. Database System – Data Independence, Relational Systems

15. Database System Architecture – Three Levels, Mapping, DBA, Database

Management Systems.

16. Object Oriented Programming Concepts - Data Types, New Operators, Classes and access Specifiers, Array of Objects, Managing Console I/O stream class, Formatted and Unformatted Console I/O – Usage manipulator

17. Functions in C++ : Call by reference, Function Overloading and default argument, static lass member, friend function.

18. Constructors and Destructors – Types, Usage of destruct

19. Operator Overloading – Overloading Unary and Binary Operators, Overloading using friend function, Usage of this pointer, Overloading insertion and extraction.

20. Inheritance – Types, Virtual Base class and abstract class, Virtual function and pure virtual function.

21. Working with Files – File Operations, File Pointers and manipulations, File Updation with random access

22. Templates : Class Template, function Templates, Overloading of Template Functions, Basics of Exception Handling.

Textbooks :

1. Let us C - Kanitkar
2. Object Oriented Programming with C++ - E. Balagurswamy.

MT 303 DATA STRUCTURES

Basics of digital Electronics: Bits, Bytes, Binary Addition ,Subtraction, Gates, Boolean Algebra, Half Adder, Half-subtractor, Full-adder, 2's Compliment method of subtraction, De-Morgan's Theorems, Flip-Flops, Registers

1. Uni-Processors: Computer Organization, History of microprocessors, Microprocessor Architecture, RAM ,ROM, Instructions set, Machine and Assembly Language, Instruction Decoding, Microprocessor Performance and trends, Progression of Intel Microprocessor, Architecture of 8086,80286,80386,80486,80586.
Storage Devices : Magnetic Storage, Optical CR - R/ CD - RW

2. Input Output Devices: Keyboard, Mouse, Introduction to Computer Monitors: The Basics, Display Technology: Background, VGA, DVI, Viewable Area, Maximum Resolution and Dot Pitch, Power Consumption, Monitor Trends: Flat Panels, Introduction to Printers: Inkjet Printers ,Working, Impact vs. Non-impact, Paper and Ink, Introduction

to Laser Printers: The Basics of Static Electricity, Drum, Fuser, Toner.

3. Introduction to Parallel computing: Concepts and Terminology, von Neumann Computer Architecture, Flynn's Taxonomy ,Some General Parallel Terminology, Parallel Computer Memory Architectures: Shared Memory ,Distributed Memory, Parallel Programming Models: Overview Shared Memory Model ,Threads Model .Message Passing Model ,Data Parallel Model Designing Parallel Programs :Automatic vs. Manual Parallelization ,Understand the Problem and the Program ,Partitioning Communications, Synchronization ,Data Dependencies ,Load Balancing Parallel Examples : Sistolic and Wave front Array Processor ,PI Calculation Simple Heat Equation ,l-D Wave Equation

4. Introduction – Data Types, Data Structures, Arrays as Abstract Data Type
1-d,2-d, Multidimensions

5. Stacks – Push and Pop Operations, Stack Implementations using C, Stack Applications, Recursions,

6. Queues – Concepts, Queue Applications, Priority Queues

7. Linked Lists – Static implementation using arrays, Doubly Linked List, Circular List, Linked List Applications, Polynomial Representation, Stacks and Queues as Linked Lists

8. Trees – Terminology and Concepts, BinaryTree Representation, Linked Representation , Binary Search Tree, Operations, Tree Traversals, Representing General Trees as binary Tree

9. Sorting – Need and concepts, Techniques like Bubble, Quick, Selection, Insertion, Tree, Merge, Radix

10. Graphs – Concepts, Graph Representation, Adjacency Matrix, Multilist, Traversals.

Text Books :

1. K Hwang and FA Briggs : Computer Architecture
2. Data Structures using C - Tenenbaum, Langsam, Augenstein.
3.Art of Computer Programming, D.Knuth (Prentice hall publishers).

MT 401 - JAVA PROGRAMMING

1. Introduction to Java Programming - Overview, Java Tools, Java Byte Code

2. Elementary Programming Concepts - Variables & Identifiers, Java keywords, Data Types, Operators, Expression, Constants, Statements, Arrays

3. Classes and Packages - Defining classes, Static Members, Using packages, Access Specifiers, Constructors, Finalisers referencing objects

4. Inheritance, nested and inner class - Extending classes, Abstract Class Interface, Super Keyword, Final classes, Constructors and Inheritance, Dynamic Binding, Overriding methods

5. Exception and Input and Output - Byte streams, Character streams, File i/o basics, Introduction to exception, Try and catch block and finally block, Inbuilt Exception.

6. String Handling and Exploring Java.lang - String Operations, Character Extractions, Data Conversions, Modifying strings.

7. Applet and Event Handling and Controls

8. Input and Output package - Object serialization, reader and writer

9. Swings - Layout Manager Layout Manager swing Controls Components Organizers, Jlish, Jtree, Jtables, Dialogue, File chooser, color chooser.

10. JDBC - The design of JDBC, JDBC programming concepts making the connection, statement and result set class, Executing SQL commands, Executing Queries.

11. Multithreading - Running multiple threads, The runnable interface Threads priorities Daemon, Thread States, thread groups Synchronization and Interthread Communication Deadlocks.

Textbook :

A Complete Reference Java 2 - Herbert Schildt.

MT 402 - OPERATING SYSTEMS

1. Introduction to Operating Systems - Batch System, Time sharing system, personal computer system, Parallel system, Distributed System, Real Time System

2. File System - File Systems, File Concepts, Allocation Methods, Access Methods, Directory Structure

3. Threads - Overview, Multithreading models, Threading Issues.

4. CPU Scheduling - Basics, Scheduling criteria, Scheduling Algorithms, Multiple Processor Scheduling.

5. Disk and Drum Scheduling

6. Memory Management - Background, Swapping, Contiguous allocation, Paging, Segmentation, Segmentation and paging- combined system, virtual memory concept, Demand paging, Paging replacement algorithms.

7. Concurrent Processing and programming - Review of process concepts, Hierarchy of processes, Problem and solution algorithm, Semaphores, Overview of Concurrent programming, Modularization, Synchronization in Windows 2000, Concurrent languages.

8. Deadlocks - System model, Deadlock characterization, methods of handling Deadlocks, Deadlock Prevention, Deadlock Avoidence, Deadlock Detection, Recovery from Deadlock.

Textbook :

Operating System concepts by Silberschatz 6th edition

MT 403 DESIGN AND ANALYSIS OF ALGORITHMS

1. Mathematical Foundation, Growth Functions, Summations, Recurrences Substitutions, Iterations, Master Methods, Counting and probability

2. Sorting, Heap Sort, Quick Sort, Merge Sort, Sorting in linear Time, Medians and Order Statistics

3. Dynamic Programming - Matrix chain Multiplication, longest common subsequence, optimal polygon triangularisation.

4. Greedy Algorithm.

5. Graphs - Traversals, Topological sort, Minimum spanning trees, single source shortest path, All pair shortest path, Maximum flow problems.

6. Sorting Networks - Comparision, bitonic sort and merge sort networks

7. Parallel Algorithms - CRCW, EREW algorithms efficiency sorting linear system problem, Matrix Operations, Strassens Algorithm and matrix inversion.

7. FFT - Polynomials DFT, FFT

8. Number Theoretic Algorithm - Rabin - Karp, KMP, Bower - Moore algorithms

9. Geometric Algorithms - Finding convex hall, closes pair of points, linear programming problem

10. NP Completeness - P and NP classes, NP completeness and reducibility

11. Approximation Algorithms - Vertex cover problem, traveling salesman problem, set covering and subset sum problems

Textbook :
1. Introduction to Algorithms : T. H Coreman, Leiserson, Rivest.

MT 01 - OPERATIONS RESEARCH

Unit I - Kuhn – Tucker conditions of Optimality – Quadratic Programming
(Sections 19.2.2B, 20.2.2)

Unit II - Inventory Models
(Sections 14.1 to 14.3)

Unit III - Queueing Models
(Section 15.1, 15.2, 15.4, 15.5)

Unit IV - Project Scheduling By PERT – CPM
(Sections 13.1 to 13.4)

Unit V - Simulation Modeling with SIMNET – II
(Sections 17.1 to 17.10)

Textbook : Hamdy A.Taha, Operations Research, Fifth Edition, Prentice Hall of India.

MT 02- INTEGRAL TRANSFORMS

A) Classification of Liner Integral Equations : Fredholm, Volterra, Integro-Differential Equations, Singular Integral Equations, Converting Volterra Equation to ODE, Conversion of IVP to Volterra equation Conversion of BVP to Fredholm equation

B) Fredholm Intergral Equations - Decomposion method, Direct Computation method, successive approximation method, method of successive substitutions, Homogeneous Fredholm Equations, Comarison between alternative methods.

C) Volterra Interal Equation - Adomian Decomposion method, Series solution method, converting Volterra equation to VIP, Successive Approximation method, successive substitution method, comparison between alternative methods.

D) Integro-Differential Equations - Introduction, Direct Computation method, Adomian Decompostion Method. Conversion to Fredholm integral Equation.Volterra Intego-Differential equations Series Solution, Decomposition Method, Conversion to IVP.

E) Singular Integral Equations - Abel problem , Genralized Abel Integral Equation, Weakly-singular Volterra Equations.

F) Non Liner Integral Equation`s - Non liner Fredholm Integral equations,Direct Computation, decomposition method, Non liner Volterra Integral Equation, Series solution, Decomposition method

G) Existence and uniqueness of solutions using fixed-point theorems in cash of Liner and nonliner Volterra and Fredholm integral equations.

H) Fourier Transforms : [FT] Definition Properties evaluation of Fourier and inverse Fourier transforms of functions, Convolution theorem for FT. Sine and Cosine Fourier transforms. Solving differential equations and interal equations using FT.

I) Laplace Transform :Definition Properties, evaluation of Laplace and Inverse Laplace transforms of functions. Convolution theorem for Laplace Transforms.Solving initial value problem using Laplace Transforms.Solving integral equation using Laplace Transforms.

J) Mellin Transforms : Definition, properties and evaluation of transforms, Convolution theorem for Mellin transforms, Applications to integral equations.

Reference Books:

1) A First course in integral equations –A.M. Wazwaz (1997) (world Scientific)

2) Introduction to Integral Equation with Applications –A.J. Jerri (1999)Second edition Wiley Interscience.

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MT 03 - NUMBER THEORY

1. Congruences : Solutions of congruencs. Chinese Remainder Theorem,Techniques of numerical calculation Public-Key Crytography.

2. Prime power moduli. Prime modulus. Primitive roots and power residues, Congruences of degree two.

3. Quadratic Residues, Quadratic Reciproctiy.

4. Greatest integer function, Arithmetic functions, Multiplicative functions,Dirichlet multiplication. Mobius Inversion Formula.

5. Diophantine equations. The equation ax + by = c, Pythagorean triangles, Assorted examples. Rational points on curves.

Books: 1.Niven and Zuckerman, An introduction to the Theory of Numbers,Wiley Publishers.

2.David Burton,Elementary Number Theory.

MT 04 - CODING THEORY

1. Error detection: correction and decoding: Communication channels,Maximum likelihood decoding,Hamming distance,Nearest neighbour / minimum distance decoding, Distance of a code.

2. Linear codes: Vector spaces over finite fields,Linear codes, Hamming weight, Bases of linear codes, Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with a linear code,Decoding of linear codes, Cosets, Nearest neighbour decoding for linear codes, Syndrom decoding.

3. Cyclic codes: Definitions, Generator polynomials, Generator and parity check matrices, Decoding of cyclic codes, Burst-error-correcting codes.

4. Some special cyclic codes: BCH codes, Defintions, Parameters of BCH codes, Decoding of BCH codes.

Reference: 1. San Ling and Chaoing xing, Coding Theory- A First Course
2. Applied Abstract Algebra - Lid and Pilz 2nd Edition

MT 05 - GRAPH THEORY

1. Fundamental concepts : Definitions and examples, graphs as models, matrices and isomorphism, paths, connected graphs, bipartite graphs, extremality vertex degree, the Pigeonhole principal, Turan`s theorem, degree sequences, graphic sequences, degree and digraphs.

2. Tree and Distances : Properties of tree, distance in graphs, stronger results, disloint spanning trees, shortest paths, tress in computer science, Eulerian circuits.

3. Matching and Factors : Matching in bipartite graphs, maximum matchings, Hall`s matching conditons, Min-Matching in bipartite graphs, sets, applications and algorithms, maximum bipartite matching, weighted bipartite matching, in general graphs, Tutte`s 1-factor theorem,f-factors of graphs.

4. Connectivity and Paths : Cuts, connectivity, edge-connectivity, blocks, 2-connected graphs, connectivity of digraphs, k connected and k-edge connected graphs, applications of Meger`s theorem, Network flow problems maximum network flow, integral flows.

5. Edges and cycles : Line graph and edge-colouring, Hamiltonian cycles: necessary conditions, Sufficient conditions.

Recommended Book:

Douglas B. West, Introduction to Graph Theory Prentice- Hall, New Delhi (1999)

Reference Books:

1. John Clarke and D.A. Holton, A First Look at Graph Theory, Allied Publisher (1991)

2. Nora Harsfield and Gerhard Ringel , Pearls Theory, Academic Press (1990)

3. Harary, Graph Theory, Narosa Publishers, New Delhi (1989)

MT 06 - LATTICE THEORY

Two definitions of lattices, Hasse diagrams, homorphism, isotone maps, ideals, congruence relations, congruence lattices, the homorphism theorem, product of lattices, complete lattice, ideal lattice, distributive –modular inqualities and identifies, complemets, pseudocomplements, Boolean lattice of pseudocomplements, join and meet-irreducible elements.

Characterizatin theorems and representation theorems-Dedekind`s modularity criterion Bikhoff`s distributivity criterion, hereditary subsets, rings of sets, Stone theorems,Nachbin theorem, staements of Hashimoto`s theorem.

Modular lattices, isomorphism theorem, Upper and lower covering conditions, Kurosone theorem, independent sets (Drops results involving projectivity and sublattice generated by sets / elements)

SeMTodular lattices Jordan-Holder chain condition, Modular pair, M-sysmmetric lattices.

Book- Genral Lattice Theory

Auther- G. Gratzer (Academic Press 1978)

Chap. 1 Section 1,2,3,4,6, Cha. 2 Section-1, Chap.3. Section –1,2.

MT 07 - COMPUTATIONAL GEOMETRY

The course text will be We will cover most of the book, adding some additional material.

1. Geometric primitives [Chap. 1]

2.Line intersection [Chaps. 2] plus randomized incremental

3. Triangulation and visibility and [Chaps. 3,15]

4. Linear programming in two and three dimensions [Chap. 4]

5. Orthogonal range searching [Chaps. 5,10]

6. Point location and Binary Space Partitions [Chaps. 6,12]

7. Voronoi diagrams and Delaunay triangulation [Chaps. 7,9]

8. Convex hulls [Chap. 11]

9. Non-orthogonal range searching [Chap. 16]

10. Curved Elements (Bezier, B-Splines)
11. Curve Reconstruction (reconstruction a curve(surface) from sample points**)**

12. 3-Dimensional Geometry

Text Book :

Computational Geometry Algorithms and Applications, 2nd ed., by de Berg, van Kreveld, Overmars, and Schwarzkopf (Springer-Verlag, 2000).

MT 08 - CRYPTOGRAPHY

1. Introduction : Overview of course, Classical cryptography [parts of Chapter 1].

2. Secret Key Encryption : Perfect Secrecy - One time pads [Chapter 2.1], Stream ciphers and the Data Encryption Standard (DES) [Chapter 3

(excluding 3.6)], The Advanced Encryption Standard (AES) - adopted September 2000.

3. Public Key Encryption : Factoring and the RSA encryption [Chapter 4.1 - 4.4], Discrete log. Diffie-Hellman Key Exchange [Chapter 8.4 (only pages 270-273)]. ElGamal encryption [Chapter 5 (only pages 162-164)] , Digital Signatures [Chapter 6 (excluding 6.5 - 6.6)], One-time signatures, Rabin and ElGamal signatures schemes, Digital Signature Standard (DSS).

4. Hashing : Motivation and applications. Cryptographically Secure Hashing. [Chapter 7.1-7.3,7.6], Message Authentication Codes (MAC). HMAC, Network Security , Secure Socket Layer (SSL), I Psec.,Secret Sharing, Definition. Shamir's threshold scheme [Chapter 11.1], Visual secret sharing schemes.

Reerence Book :

D. R. Stinson. *CRYPTOGRAPHY: Theory and Practice.* CRC Press. 1995.

MT 09 - FINANCIAL MATHEMATICS

1. Introduction to options and markets: types of options, interest rates and present values.

2. Black Sholes model : arbitrage, optionvalues, pay offs and strategies, putcall parity, Black Scholes equation, similarity solution and exact formulae for European options, American option, call and put options, free boundary problem.

3. Binomial methods : option valuation, dividend paying stock, general formulation and implementation.

4. Monte Carlo simulation : valuation by simulation

5. Finite difference methods : explicit and implicit methods with stability and conversions analysis methods for American options- constrained matrix problem, projected SOR, time stepping algorithms with convergence and numerical examples.

6. Lab component: implementation of the option pricing algorithms and evaluations for Indian companies.

References:

1. D.G.Luenberger, Investment Science, Oxford University Press,1998.

2. J.C.Hull , Options, Futures and Other Derivatives, 4th ed., Prentice- Hall ,New York,2000.

3. J.C.Cox and M.Rubinstein, Option Market, Englewood Cliffs,N.J.: Prentice-Hall,1985.

4. C.P. Jones. Investments, Analysis and Measurement, 5th ed.,John Wiley and Sons,1996.

MT 10 - MODELLING AND SIMULATION

1. Introduction to modelling and simulation. System analysis, clasification of systems. System theory basics, its relation to simulation.

2. Model classification: conceptual, abstract, and simulation models. Heterogeneous models. Methodology of model building

3. Simulation systems and languages, means for model and experiment description. Principles of simulation system design

4. Parallel process modelling. Using Petri nets and finite automata in simulation
Models o queuing systems. Discrete simulation models. Model time, simulation experiment control.

5. Continuous systems modelling. Overview of numerical methods used for continuous simulation.

6. Combined simulation. The role of simulation in digital systems design

7. Special model classes, models of heterogeneous systems.

8. Checking model validity, verification of models. Analysis of simulation results

9. Simulation results visualization. Interactive simulation

10. Design and control of simulation experiments. Model optimization

11. Generating, transformation, and testing of pseudorandom numbers. Stochastic models, Monte Carlo method

12. Overview of commonly used simulation systems.\

References :

1. Fishwick P.: Simulation Model Design and Execution, PrenticeHall, 1995, ISBN 0-13-098609-7

2. Law A., Kelton D.: Simulation Modelling and Analysis, McGraw-Hill, 1991, ISBN 0-07-100803-9

3. Rábová Z. a kol: Modelování a simulace, VUT Brno, 1992, ISBN 80-214-0480-9

4. Ross, S.: Simulation, Academic Press, 2002, ISBN 0-12-598053-1.

MT 11 - ARTIFICIAL INTELLIGENCE

1. Overview of history and goals of AI : Tentative definitions. Turing's test. Knowledge vs. Symbolic Level. Relations with other disciplines, from Philosophy, to Linguistics, to Engineering. Review of AI successes and failures.
2. State Spaces, Production Systems, and Search : State Space representation of problems. Problem solving as search. Constraints. Definition and examples of Production Systems. Heuristic search techniques. Two person games.
3. Knowledge Representation Issues: Procedural Knowledge Representation vs. Declarative Knowledge + Reasoning. Facts, General Assertions, Metaknowledge. The Frame Problem.
4. Using First-Order Logic for Knowledge Representation : Propositional Logic: Semantics and Deduction. First Order Logic: Semantics and Deduction. Unification. Resolution-based theorem proving. Using theorem proving to answer questions about the truth of sentences or to identify individuals that satisfy complex constraints. Logic Programming.
5. Common Sense Reasoning : Nonmonotonic reasoning and modal logics for nonmonotonic reasoning. How to deal with Agents and their Beliefs.
6. Weak Slot-and-Filler Structures: Semantic Nets and Frames. Scripts for representing prototypical combinations of events and actions.
7. Rule-Based Systems: Pattern-matching algorithms. The problem of Control in Rule Based Systems. The Rete Algorithm.
8. Planning: Representing plans. Partial order planning. Planning applications.
9. Statistical Reasoning: Use of Certainty Factors in Rule-Based Systems. Associating probabilities to assertions in first-order logic. Bayesian Networks. Fuzzy Logic.
10. Learning: Learning to classify concepts using features of their instances. Learning a concept [Induction] from examples. Explanation-Based Learning. Version Spaces. Neural Nets with back propagation.

Text Book :

Artificial Intelligence: A Modern Approach : Prentice-Hall, 1995

MT 12 - SYMMETRIES

1. Symmetry of plane figures of motions of the plan, finite groups of motions, discrete groups of motion, symmetry, cosets, counting formula, permutation representations, finite subgroups of the generators and relations

2. Operation of a group on itself, class equation of the isocahedral groups operations on subsets groups of order12, free group generators and relations.

3. Bilinear forms, symmetric forms, orthogonality, geometry associated to a positive from, Hermitian forms, spectral theorem, conics and quadrics, normal operators, skew symmetric forms.

Text: Artin: Algebra (Prentice-Hall)

Chapter 5, 6 (sections 1, 2, 3 and7)

MT 13 - WAVELET ANALYSIS

1. Fourier Transform : Fourier transform on $L^1(R)$ and $L^2(R)$ and basic properties and examples

2. Windowed Fourier Transform : Motivation and definition of Windowed Fourier Transform and examples, Time frequency localization, the reconstruction formula.

3. Continuous Wavelet Transform : Motivation and Definition of the wavelet transform and examples, Basic properties, The reconstruction formula, Frequency localization, Orthonormal Wavelets.

4. Multiresolution Analysis : Definition of MRA and examples, Properties of scaling functions and orthonormal wavelets bases, Construction of orthonormal wavelets.

Textbook :

1. Bachman G, L. Narici & E. Beckensterin: Fourier and Wavelet Analysis, Springer-Verlage (2000)
2. Chui C. K. : An Introduction to Wavelets, Academic Press (1992)

.

MT 14 - COMBINATORICS

1. Counting Methods for selections arrangements : Basic counting principles, simple arrangements and selections, arrangements and selection with repetition , distributions, binomial, generating permutations and combinations and programming projects.

2. Generating function : Generating function models, calculating of generating functions, partitions exponential generating functions, a summation method.

3. Recurrence Relations : Recurrence relation model, divide and conquer relations, solution of inhomogeneous recurrence relation, solution with generating functions.

4. Inclusion-exclusion : Counting with Venn diagrams inclusion formula, restricted positions and rook polynomials.

5. Ramsey Theory : Ramsey theorem, applications to geometrical problems.

Recommended Books:

1. Alan Tucker, Applied Combinatorics (third edition), John Wiley & sons , New York (1995)

2. V. Krishnamurthy, Combinatorial, Theory and Applications, East West Press, New Delhi (1989) Scientific, (1996)

MT 15 - PARTIAL DIFFERENTIAL EQUATIONS

1. First order PDE, Linear Equations of first order, Charpit's method, Jacobi's method, Quasi-linear equations, Non-linear first order PDE.

2. Second ordered PDE: Genesis, Classification, One dimensional Wave equation, Laplace equation, Boundary Value Problems, Maximum and Minimum Principles, Cauchy Problem,

3. Heat Conduction Problem, Duhamel's Principle

Text Book :-

An Elementary Course in Partial Differential Equations by T. Amaranath (Narosa) Chapters 1-2.

MT 16 - FUZZY LOGIC

1. Fuzzy Sets and Operations on Them

2. Fuzzy Relations

3. Fuzzy Rules

4. Approximate Reasoning

5. Fuzzy Logic

6. Fuzzy Systems (e.g., Fuzzy Logic Control)

7. Fuzzy Logic in Pattern Recognition

8. Fuzzy Decision Making

9. Fuzzy Logic Applications

TextBook :

George J. Klir, Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall PTR, 1995.

Hao Ying, *Fuzzy Control and Modeling: Analytical Foundations and Applications*, IEEE Press, 2000. (Do not need to buy it. A handout will be distributed).

MT 17 - STATISTICS AND PROBABILITY

1. Introduction to Discrete Probability : Intuitive concepts: probability of an event as a measure between 0 and 1; random variable; probability distribution; frequency interpretation of probability; random numbers; coins, dice, and other games; simulations; odds; historical development of probability; random walks.

2. Formal concepts: sample space, outcomes, and events; random variable; discrete distribution functions and axioms of probability; unions, intersections, and complements; properties of probabilities, principle of inclusion and exclusion; tree diagrams; uniform distributions over finite sets, symmetry; infinite sample spaces with discrete probabilities.

3. Introduction to Continuous Probability : The intuitive problems with probabilities over space (line, plane, $\mathbf{R}^n$ in general). Monte Carlo simulations, Buffon's needle. Formal concepts: density function for a continuous random variable; integration; cumulative distribution functions; derivatives; exponential density function;

4. Conditional Probability : Intutive concept of conditional probability; formal definition of conditional probability; Bayes' formula for inverting conditional probabilities; independent events; joint distribution functions; independent random variables; independent trials. Conditional density functions for continuous distributions; the beta distribution

5. Distributions and Densities : Uniform continuous distributions; geometric distribution; Poisson distribution; exponential and gamma distributions; introduction to queueing theory; normal (Gaussian) distribution; Chi-squared distribution

6. Expected Value and Variance : Expected value for discrete random variables, expectation; linearity of expectation; expectation of independent random variables; conditional expectation; variance and standard deviation; variance of various distributions. Expectation and variance for continuous random variables.

7. Sums of Random Variables : Analysis of sums of independent random variables with identical distributions, that is, independent trials.

8. Law of Large Numbers : Chebychev inequality, law of averages, law of large numbers.

9. The Central Limit Theorem : The central limit theorem for Bernoulli trials, binomial distributions again, the normal distribution, the general central limit theorem.

TextBook :

Charles M. Grinstead and J. Laurie Snell's textbook *Introduction to Probability*, published by the American Mathematical Society, 1997

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MT 18 - FLUID DYNAMICS

1. Physical Properties of fluids. Concept of fluids, Continuum Hypothesis, density, specific weight, specific volume.

2. Kinematics of Fluids : Eulerian and Lagrangian methods of description of fluids, Equivalence of Eulerian and Lagrangian method, General motion of fluid element, integrability and compatibility conditions, strain rate tensor, stream line, path line, streak lines, stream function¸ vortex lines, circulation.

3. Stresses in Fluids : Stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor.

4. Conservation Laws : Equation of conservation of mass, equation of conservation of momentum, Navier Stokes equation, equation of moments of momentum, Equation of energy, Basic equations in different co-ordinate systems, boundary conditions.

5. Irrotational and Rotational Flows : Bernoulli's equation, Bernoulli's equation for irrotational flows, Two dimensional irrotational incompressible flows, Blasius theorm, Circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows, methods of images.

TextBooks :

1. An introduction to fluid dynamics, R.K. Rathy, Oxford and IBH Publishing Co. 1976.
2. Theoretical Hydrodynamics, L. N. Milne Thomson, Macmillan and Co. Ltd.
3. Textbook of fluid dynamics, F. Chorlton, CBS Publishers, Delhi.
4. Fluid Mechanics, L. D. Landau and E.N. Lipschitz, Pergamon Press, London, 1985.

MT 19 - BANACH ALGEBRA

1. Relatively compact sets, compactly continuous operators, finite dimensional operators, transformation that is bounded but not completely continuous, a type of transformation that is always completely continuous, further properties of completely continuous transformations.

2. Spectra and the resolvent set, Approximate proper values, Banach Algebra With identity, compactness of the spectrum, the resolvent operator, Spectral radius and spectral mapping theorem for polynomials, the Gelfand Theory.

3. Sesquilinear functions : Spectral results for normal and completely continuous operators, numerical range

4. The Fredholm alternative theory, the spectral theorem for bounded, normal Finite dimensional operators.

5. Commutative Banach Algebras, ideals and homomorphisms.

TextBook :
1. Walter Rudin: Functional Analysis, Tata MeGrow Hill Publishing co. New Delhi.

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MT 20 - BOUNDARY VALUE PROBLEMS

1. Definition of boundary Value Problems, the heat equation, wave equation, Laplac`s equation, the Fourier method, Liner Operators, Principal of Superpositin, series solutions, uniform convergence (weierstrass M-test), separation of variables, non homogeneous conditions, Sturm-Liouville problems, formal solutions, the vibrating string.

2. Orthogonal sets of functions, Generalized Fourier series, Best approximation in the mean, Convergence in the mean, the orthonormal trigonometric functions, other types of orthogonality.

3. sturm-Liouville Problem and applications, orthogonality and uniqueness of eigenfunctions, method of solutions, surface heat transfer other boundary value problems.

4. Bessel function J_n, recurrence relation, the zero of J_o (X) and related functions, Fourier-Bessel series, Temperatures in a long cylinder.

5. Legendre polynomials, orthogonality of Legendre polynomicals, Legendre series, Dirichlet Problem in spherical regions.

Prescribed Text Book

R.V. Churchill and J. Brown.: Fourier Series and Boundary Value Problems (4^{th} edtion)(Publisher: McGraw-Hill Book Company)

MT 21 - BAER* RINGS

1. Rings with involution
2. Poset of projections
3. Proper involutions and C*-algebras
4. Rickart ***-**rings and Bear *-ring
5. Weakly Rickart *-rings and unitification
6. Central cover
7. Additivity of projections
8. Comparability axioms and parallelogram law
9. Finite and abelian projections
10. Structure Theorem

Prescribed Book: Bear *-rings, S.K. Berberian, Springer

MT 22 - MATROID THEORY

1. Basic definitions and examples

Independent sets and circuits, bases, rank, closure, geometric representations of matroids of small rank, transversal matroids, the lattice of flats, the greedy algorithm.

2. Duality

The defination and basic properties, duals of representable matroids, duals of graphic matroids, duals of traversal matroids.

3. Minors

Contraction, Minors of certain matroids, flats and the sum theorem

4. Connectivity

Connectivity, for graphs and matroids, properties of matroid connectivity, more properties of connectivity.

Text Book:

James G. Oxley, Matroid Theory Science Publications, Oxford (1992)(Chapter 1 to 4)

MT 23 - SPERNER THEORY

1. Introduction and sperner`s Theorem: A Simple intersection result, Sperner`s theorem, Theorem of Bollobaas.

2. Normalized Matching and rank numbers: Sperner`s proof,system of distinct representatives, L Y M inequalities, and normalized matching property. Rank numbers, some examples.

3. Systemmebric Chain: Sysmmertric chain decompositions, Dilworth`s theorem, symmetric chains of sets, Application to Nested chains, posets with sysmmetric chain decompositions.

4. Rank numbes of multisets. Unimodality and log connectivity, the normalized matching property. The largest size of a rank number.

Prescribed Text Book

Ian Anderson : Combinatorics of Finite Sets. (Oxferd Science Publications)

Reference Book.

Konrad Engel: Sperner Theory (Cambride University Press)

MT 24 - DIFFERENTIAL EQUATIONS AND DYNAMICAL SYSTEMS

1) Liner Systems: Uncoupled Liner Systems, Diagonalization, Exponential of operators Fundamantal theorem for liner systems, liner systems in R, Complex eigenvalues, multiple eigenvalues, Jordan Canonical Forms, stability theory Nohomogeneous Liner systems.

2) Nonlinear Systems: Local Theory, Fundamental existence theorem dependence on initial conditions and parameters, the maximal interval of existence, Flow defined by a differential equation. Linearization, stable manifold theorem, Hartman-Grobman theorem, Stability and Liapunov functions, Saddles, Nodes, Foci and centers, Nonhyperbolic critical points in R_n, Gradient and Hamiltonian system.

Text (1) L. Perko- Differential Equations and Dynamical systems (1991) Springer-verlag

(2) Hirsch and Smale – Differential Equations, Dynamical Systems, and Liner Algebra - Academic Press, New York, (1974)

MT 25 - MECHANICS

1. Sec 1.1-1.6 Survey of Elementary Particles
2. Sec. 2.1-2.7 Variational Principles & Lagranges` Equation
3. Sec.3.1-3.7 Central Force problem
4. Sec. 4.1-4.10 Kinematics of rigid body motion
5. Sec. 8.1-8.2 Hamilton Equations of motion
6. Sec.9.1-9.9 Canonical Transformations

Text Book: Classical Mechanics by Goldstein, Poole and Safko (Third Edition) 2002, Person Education Inc. Supplementary Reading (1) Rana & Joag Classical Mechanics (Tata McGraw Hill)