SEMESTER I

20SA11 CONTEMPORARY ALGEBRA

4004

GROUPS: Groups - Subgroups - Normal subgroups - Factor group - Cayley’s theorem – Sylow’s theorem. (10)


FIELDS: Definition – subfields - Finite fields – structure of Finite field. (6)

VECTOR SPACES: Linear spaces, subspaces- Linear independence, basis, dimension - Dual spaces - Inner product spaces. (12)

LINEAR TRANSFORMATIONS: Definition and examples, null Space and the range space, rank-nullity-dimension theorem. Isomorphism between vector Spaces, matrix representation of a linear transformation, matrix for the composition and the Inverse. Similarity transformation, Linear functional. (12)

EIGENVALUES AND EIGEN VECTORS: Eigen values, eigenvectors, characteristic polynomial, Cayley-Hamilton theorem, diagonalization. (6)

TEXT BOOKS:

REFERENCES:

20SA12 REAL ANALYSIS

4004

METRIC SPACES: Definition and examples, compact sets, Heine-Borel theorem, continuous functions, uniform continuous functions. differentiation- mean value theorem, Taylor’s theorem. (14)

THE RIEMANN STIELTJES INTEGRAL: Riemann Integral - definition and existence of integral, properties of the integral. Riemann Stieltjes Integrals, integration and differentiation. (12)

SEQUENCES AND SERIES OF FUNCTIONS: Uniform convergence, uniform convergence and continuity, differentiation and integration. Equi-continuous families of functions. (12)

LEBESGUE MEASURE: Introduction, Lebesgue outer measure, - algebra of Lebesgue measurable sets, outer and inner approximations, countable additivity, continuity, Borel-Cantelli Lemma. Lebesgue measurable functions. (12)

LEBESGUE INTEGRATION: The Lebesgue integral - bounded measurable functions over a set of finite measure, measurable and non-negative functions, The general Lebesgue Integral. (10)

TEXT BOOKS:

REFERENCES:
20SA13 DIFFERENTIAL EQUATIONS


SYSTEM OF ORDINARY DIFFERENTIAL EQUATIONS: System of first order ODEs – Fundamental matrix – Non-homogeneous linear systems – Linear system with constant coefficients – Picard’s theorem – Continuation and dependence on initial conditions – Existence and uniqueness of solutions. (9)

PARTIAL DIFFERENTIAL EQUATIONS: Introduction – Classification of integrals – Linear equations of the first order - Integral surface passing through the given curve – Pfaffian differential equations – Compatible systems – Charpit’s method – Jacobi’s method. (9)


Total L : 45

TEXT BOOKS:

REFERENCES:

20SA14 PROBABILITY, STOCHASTIC PROCESSES AND STATISTICS

SAMPLE SPACE AND PROBABILITY: Sets, probability models, conditional probability, total probability theorem, Bayes’ rule, independence, counting. (6 + 4)


LIMIT THEOREMS: Markov and Chebyshev inequalities, Law of Large Numbers, Convergence in probability, Central Limit Theorem. (7 + 4)

STOCHASTIC PROCESSES: Bernoulli and Poisson process, Markov chains- Discrete- Time Markov chain, Classification of states, steady-state behavior, absorption probability and expected time to absorption, period, Continuous-Time Markov chains-Birth and death process. (10 + 7)


Total L : 45 + T:30 = 75

TEXT BOOKS:

REFERENCES:
20SA15 DISCRETE MATHEMATICS


RELATIONS AND FUNCTIONS: Definition and properties of binary relations – Representing relations – Closures of relations – Composition of Relations – Equivalence relations – Partitions and covering of Sets – Partial Orderings – n-ary Relations and their applications. Functions-Injective, surjective, bijective functions, Composition, Identity and Inverse. (8)


COMBINATORICS: Basics of counting – The Pigeonhole principle - Permutations and Combinations with and without repetition, Permutations with indistinguishable elements, distribution of objects - Generating permutations and combinations in lexicographic order. (8)

RECURRENCE RELATIONS: Recurrence Relation Models- Solutions of linear homogeneous recurrence relations with constant coefficients- solution of linear non-homogeneous recurrence relations by the method of characteristic roots - Divide and conquer recurrence relations. (11)

Total L : 45

TEXT BOOKS:

REFERENCES:
20SA16 PROBLEM SOLVING AND C PROGRAMMING

3 0 0 3

PROBLEM SOLVING: Introduction to Problem Solving- Program development- Analyzing and Defining the Problem – Algorithm-Flow Chart - Programming languages-Types of programming languages- Program Development Environment. (4)

C LANGUAGE: Introduction to C Language - C Character Set - Identifiers and Keywords - Data Types – Literal Constants - Variables – l-value-r-value - Qualifiers – Modifiers - Operators and Expressions – Type conversions - Library Functions - Data Input and Output Functions – escape sequence characters – Formatted input and output. (4)


ARRAYS: Defining Array –Array Initialization - Accessing array elements - Processing arrays - Arrays as function arguments - Multidimensional arrays – Memory address calculation of an array – Row major and column major order - String Handling.(5)

POINTERs: Pointer Variable Definitions and Initializations – Passing Arguments to Functions by address – Pointer Expressions and Pointer Arithmetic - Relationship between Pointers and Arrays - Pointers and multidimensional arrays – Constant Pointer – Pointer to Constant –NULL pointer- dangling pointers - Pointers to functions - passing functions to other functions – Introduction to Stack and Heap Memory - Dynamic Memory Allocation. (8)


FILES: Files and Streams - Operations on Files – Types of Files, Various Read and Write Functions for Sequential-Access and Random-Access Files -Command Line Arguments. (4)


Total  L : 45

TEXT BOOKS:

REFERENCES:

20SA17 PROFESSIONAL COMMUNICATIONS

0 0 2 1

Reading Compression : Reading for Critical Purposes (2)
Presentation Skills. (2)
Introduction to Soft Skills. (2)
Interpersonal - Intrapersonal Communication (2)
Meetings . (2)
Professional Report Writing, (4)
Professional Values and Ethics – Case analysis. (4)
PRACTICALS
Short Speeches,Group Discussions, Meetings. (8)
References:
1. Course materials prepared by the faculty, Department of English

20SA18 C PROGRAMMING LAB

0 0 4 2

1. Simple programs to understand the concepts of data types.
2. Familiarizing conditional, control and repetition statements.
3. Usage of single and double dimensional arrays including storage operations.
4. Implementation of functions, recursive functions.
5. Defining and handling structures, array of structures and union.
6. Implementation of pointers, operation on pointers and dynamic storage allocation.
7. Creating and processing data files.

TOTAL P : 60

SEMESTER II

20SA21 TOPOLOGY AND FUNCTIONAL ANALYSIS

3 0 0 3

Prerequisites:
20SA11 -Contemporary Algebra,
20SA12 - Real Analysis,

TOPOLOGICAL SPACES AND CONTINUOUS FUNCTIONS: Topological spaces, basis for a topology, subspace topology, order topology, closed sets and limit points, Hausdroff spaces, product topology, metric topology-continuous functions.

CONNECTEDNESS AND COMPACTNESS: Connected spaces, connected sub sets of the real line, local connectedness, compact spaces, locally compact spaces


BANACH SPACES: Definition and examples, continuous linear transformations, Hahn-Banach theorem, the natural imbedding of a normed space, the open mapping theorem, the closed graph theorem.

HILBERT SPACES: Definition and simple properties, orthogonal complements, orthonormal sets- Bessel's inequality.

TEXT BOOKS:

REFERENCES:
20SA22 COMPLEX ANALYSIS

Prerequisites:
20SA12 - Real Analysis.

ANALYTIC FUNCTIONS AND FUNDAMENTAL THEOREMS: 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, fundamental theorem of algebra.

SERIES: 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.

RESIDUES AND POLES: Rational Functions, singularities, poles, classification of singularities, characterization of removable singularities, poles, behavior of an analytic functions at an essential singular point, conformal mapping.

COMPLEX INTEGRATION: Entire and meromorphic functions, 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.

Total L : 45

TEXT BOOKS:

REFERENCES:

20SA23 OBJECT ORIENTED PROGRAMMING

Prerequisites:
20SA16- Problem solving and C – Programming.


FUNCTIONS IN C++: Function Prototyping - Call by Reference - Return by reference - Inline functions - Default, Const Arguments - Function - Overloading. Classes and Objects - Member functions - Nesting of Member functions - Private member functions - Memory allocation for Objects - Static data members - Static MemberFunctions - Arrays of Objects - Objects as Function Arguments - Friend Functions - Returning Objects - Const Member functions - Pointers to Members


INHERITANCE AND POLYMORPHISM:: Defining Derived Classes – Types - Compile and Run Time Polymorphism - Virtual function –Overloading Unary and Binary Operators - Overloading Binary Operators using Friend functions – Operator Type conversion.

TEMPLATES : Introduction to Templates, Generic Functions and Generic Classes.

INTRODUCTION TO JAVA: Data Types - Declarations –Wrapper Classes - Arrays and Strings – Input/Output.- Java Classes andMethods - Constructors - Scope rules - this keyword.


MULTI THREADED PROGRAMMING: Java thread model - Priorities - Synchronization - Messaging - Thread class and runnable Interface - Main thread - Thread creation - Synchronization - Interthread Communication – Deadlock.
I/O: I/O basics - Stream - Stream Classes - Predefined stream - Reading/Writing console Input. (3)

GUI: Applet fundamentals - GUI Components – Event Handling. (4)

TEXT BOOKS:

REFERENCES:

20SA24 DATA STRUCTURES

Prerequisites: 20SA15 – Discrete Mathematics

INTRODUCTION: Data structures - Abstract Data Type - Primitive data structures - Analysis of algorithms- Best, worst and average case time complexities – Asymptotic notations. (6)

ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices – Applications. (4)

STACKS: Primitive operations - sequential implementation - Applications: Subroutine handling - Recursion – Expression Processing. (4)

QUEUES: Primitive operations – circular queue- Priority Queues – Dequeues. (4)

LISTS: Primitive Operations - Singly linked lists, Doubly linked lists, Circular linked lists, Multiply linked lists - Applications: Addition of Polynomials; Multiply linked list ; Sparse Matrix representation and Operations. – Linked Stacks - Linked queues - Linked Priority queues - Dynamic Storage Management. (8)

TREES: Terminologies – Binary tree: Properties - Sequential and linked representation - Common binary tree operations - Traversals - Expression trees - Infix, Postfix and Prefix expressions - Threaded trees - Heaps, Max heap, Min heap. (10)


MULTIWAY SEARCH TREES: Indexed Sequential Access – m-way search trees – B-Tree – searching, insertion and deletion. (5)

GRAPHS: Introduction-representations -Adjacency matrix, packed adjacency list and linked adjacency list – Graph search methods-Breadth first and depth first traversals. (6)

SORTING AND SEARCHING: Insertion sort, selection sort, bubble sort, heap sort, count sort and radix sort - Linear Search, Binary Search-Time Complexity. (4)

TEXT BOOKS:

REFERENCES:
20SA25 DATABASE MANAGEMENT SYSTEM

Prerequisites:
20SA15 – Discrete Mathematics


TRANSACTION PROCESSING AND CONCURRENCY CONTROL: Transactions, Locking techniques, Concurrent access, Deadlock handling.


TEXT BOOKS:

REFERENCES:

20SA27 OBJECT COMPUTING LAB

1. Arithmetic operations using array of objects and dynamic data members.
2. Creation of a class which keeps track of the member of its instances. Usage of static data member, constructor and Destructor. to maintain updated information about active objects.
3. Usage of a function to perform the same operation on more than one data type.
4. Overloading the operators to do arithmetic operations on objects.
5. Acquisition of the features of an existing class and creation of a new class with added features in it.
7. Use and create packages and interfaces.
8. Implementation of exception handling.
10. Creation of an effective GUI that handles various events performed with the appropriate actions.

TOTAL P: 60

20SA28 DATASTRUCTURES LAB

0 0 4 2

1. Sparse and dense Matrix operations using arrays.
2. Library of string operations - representing strings using arrays.
3. Stack and Queue using array.
4. Linked Lists: Singly linked, Doubly linked and Circular lists
5. Linked Stacks and Queues.
7. Binary trees and Threaded trees.
8. Hash Table linear probing and chaining.
9. BST, AVL tree implementation
10. Graph Traversal

TOTAL P: 60

20SA29 DATABASE MANAGEMENT SYSTEM LAB

0 0 21

1. Working with DDL and DML for creation and manipulation of single, multiple tables, Report Generation.
2. Practicing DCL commands to control access privileges.
3. Working with TCL commands to manage transactions in databases.
4. Working with PL/SQL- Triggers and stored procedures..
5. Developing Packages using databases.

TOTAL P: 30

SEMESTER III

20SA31 APPLIED GRAPH THEORY

3 0 0 3

Prerequisites:

Basic Concepts: Graphs, digraphs, subgraphs, graph models, graph representations, degree sequence. Walk, trail, path, connected graph, distance, diameter, clique, independent set, vertex cover. Graph isomorphism, graph decomposition. Algorithms – time and space complexities. Depth-first and breadth-first search algorithms. (10)


COLORING & PLANAR GRAPHS: Vertex-coloring – upper chromatic number, bounds using clique number, maximum degree, Welsh – Powell theorem. Sequential and largest degree first algorithms, applications to frequency assignment. Euler’s formula, dual graph, Kuratowski’s theorem, 4-color problem, Wagner’s theorem. Planarity testing – Hopcroft-Tarjan algorithm.


TEXT BOOKS:

REFERENCES:

20SA32 OPTIMIZATION TECHNIQUES

Prerequisites:
20SA15 – Contemporary Algebra.

LINEAR PROGRAMMING: Linear programming modeling – Solution techniques – Graphical method, Simplex method, Big M method, Two Phase method - Special cases of Simplex method.


DECISION MAKING: Decision making under certainty and uncertainty – decision making under risk.


FINANCIAL APPLICATIONS: Dynamic Programming approaches to solve Financial problems - Option Pricing using Binomial Lattice - Mortgage backed securities.

TEXT BOOKS:

REFERENCES:

20SA33 NUMBER THEORY AND CRYPTOGRAPHY

Prerequisites:
20SA15 – Contemporary Algebra.
**ARITHMETICAL FUNCTIONS:** Divisibility-Division Algorithm, Euclidean Algorithm; Primes-Fundamental Theorem of Arithmetic: Arithmetic function-Euler totient function.

**CONGRUENCES:** Introduction to Congruence - Definition, properties, Ring of integer modulo n, Prime field, Primitive roots, Irreducible polynomial, Chinese remainder Theorem, Euler, and Fermat Theorem, Legendre, Jacobi, and Quadratic Reciprocity.

**CRYPTOGRAPHIC PRIMITIVES:** Definitions and Illustrations: Symmetric-Key Cryptography, Classical Ciphers, Stream Ciphers, Block Ciphers LFSRs, Modes of Operation, DES, AES - Attacks.

**PUBLIC-KEY CRYPTOGRAPHY:** Principles of PKC, RSA Cryptosystem, PKC based on the Discrete Logarithm problem -ElGamal Cryptosystem and Elliptic Curve systems.

**HASH FUNCTIONS AND SIGNATURE SCHEMES:** Hash functions based on Cryptosystems, Message Digest, The RSA signature scheme, The Digital Signature Algorithm. The ElGamal signature scheme.

**KEY DISTRIBUTION AND KEY AGREEMENT:** Introduction, Key transport based on symmetric encryption - Kerberos. Key agreement based on symmetric techniques - Blom’s Scheme, Key transport based on public key encryption-Needham –Schroeder protocol, Key agreement based on asymmetric techniques- Diffie-Hellman key agreement protocol, station-to-station protocol.

**TEXT BOOKS**

**REFERENCES**

**20SA34 MACHINE LEARNING**

**Prerequisites:**
- **20SA15** – Contemporary Algebra.
- **20SA14** - Probability, Stochastic Processes and Statistics

**INTRODUCTION:** Machine learning – Types – Supervised learning, unsupervised, Reinforcement learning, semi supervised learning

**SUPERVISED LEARNING:** Regression – Linear – Polynomial – Multiple regression – Evaluation measures – Bias –variance –over fitting –under fitting – Regularization


**DECISION TREES:** Introduction – Purity measures – Entropy, cross entropy, information gain, gain ratio, Gini Index – Regression trees – ID3 – Pruning – Model selection – Bootstrapping and cross validation – Model evaluation – Performance Measures – Receiver operating characteristic curve (ROC) – AUC.


**Tutorial Practices:**
1. Download the datasets from UCI machine learning repository / www.kaggle.com for classification and clustering.
   a. Mail spam
   b. Breast cancer data

**Total L : 45 + T : 30 = 75**
c. Iris data
d. MNIST dataset

2. Implement the following Classification algorithms on the above suitable datasets.
   a. Naïve Bayes
   b. LDA / QDA
   c. SVM
   d. K nearest neighbour
   e. Multi layer Perception

3. Do tenfold cross validation experiments and statistical validation using t-test and ANOVA.
4. Apply clustering for image segmentation and image compression.
5. Apply Spectral clustering on data sets and visualization through plots
6. Apply PCA / LDA / Factor analysis on Iris data set, reduce the dimension and visualize the data.
7. Apply semi supervised learning techniques on data sets for the following tasks: to fill missing values / classification

TEXT BOOKS:

REFERENCES:

20SA37 SCIENTIFIC COMPUTING LAB

Prerequisites:
20SA11 Contemporary Algebra
20SA13 Differential Equations

4. Interpolation with unequal intervals and equal intervals.
5. Numerical Differentiation and Integration
6. Taylor’s series method, Euler’s method, Modified Euler’s method Fourth order RungeKutta method for solving first order differential equations
7. Numerical solutions of Solution of one dimensional heat equation by explicit and implicit methods – One dimensional wave equation and two dimensional Laplace and Poisson equation
8. Solving LPP using simplex method and two phase method.

TOTAL P: 30

TEXT BOOKS:

REFERENCES:

20SA38 MINI PROJECT & SEMINAR

Mini – project is to be done during the summer vacation at the end of the second semester and a seminar is to be conducted during the third semester.
Every student shall undertake a project work during the fourth semester. The project work shall be undertaken in an industrial / research organization or in the college in consultation with the faculty guide and the Head of the Department. In case of the project work at industrial / research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization.

**PROFESSIONAL ELECTIVES**

### 20SA61 ALGEBRAIC TOPOLOGY

**Prerequisites:**
- 20SA11 - Contemporary Algebra,
- 20SA12 - Real Analysis,
- 20SA21 - Topology and Functional Analysis.

**ALGEBRAIC TOPOLOGY:**
- Homotopy of Paths - The Fundamental Groups - Circle, group of $S^n$,
- Covering spaces-
- Retractions of fixed points - The fundamental theorem of Algebra.

**SEPARATION THEOREMS IN PLANE:**
- The Jordan Separation Theorem—Invariance of domain-Jordan Curve Theorem-
- Embedding graphs in a plane- Winding number of simple closed curve

**CLASSIFICATION OF SURFACES:**
- Fundamental Groups of Surfaces-Homology of Surfaces- Cutting and pasting- The classification theorem- Constructing compact surfaces.

**AXIOMATIC APPROACH TO DIGITAL TOPOLOGY:**
- Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms.

**ABSTRACT CELL COMPLEXES:**
- Topology of complexes, Cartesian complexes and combinatorial coordinates,
- AC complexes compared with other Locally Finite Spaces

**TEXT BOOKS:**

**REFERENCES:**

### 20SA62 ARTIFICIAL INTELLIGENCE

**Prerequisites:**
- 20SA14 - Probability, Stochastic Processes and Statistics,
- 20SA15 - Discrete Mathematics,
- 20SA24 - Data structures

**INTRODUCTION:**
- The foundations of AI - The History of AI - Intelligent agents - Agent based system.

**PROBLEM SOLVING:**

**KNOWLEDGE REPRESENTATION AND REASONING:**
- Knowledge representation - Logics - bivalent logic -
- Inference - Fuzzy logic: membership - Fuzzy rules and reasoning - Fuzzy inference.

**UNCERTAIN KNOWLEDGE AND PROBABILISTIC REASONING:**
- Uncertainty - Probabilistic reasoning -
- Semantics of Bayesian network - Exact inference in Bayesian network - Approximate inference in Bayesian network
Probabilistic reasoning over time – Inference in temporal models – Hidden Markov Models – Dynamic Bayesian Networks.


**Tutorial Practices**:
1. Implementation of blind search algorithms.
2. Implementation of Heuristic search algorithms like A* and Hill Climbing.
4. Constraint satisfaction techniques
5. Logic based exercises.
7. Simple games – minimax and expectimax.

**TEXT BOOKS**:

**REFERENCES**:

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**20SA63 BIG DATA AND MODERN DATABASE SYSTEMS**

**Prerequisites**:
20SA24 - Data structures,
20SA25 - Database Management System.

**OBJECT AND SPATIAL DATABASES**: Object Oriented Databases - Complex data types - Structured types and Inheritance - Query Processing in Object databases - Spatial Databases - Geometric Information System – Spatial Data Types – Spatial Queries - Spatial indexing techniques.


**DATA MODELING FOR BIG DATA**: Big Data and Challenges, Big Data models, NoSQL data models, Basic principles of NoSQL models, BASE properties, CAP Theorem, SQL databases VsNoSQL databases - MAP-REDUCE: Apache Hadoop andHDFS, SPARK.

**NOSQL DATABASES (PART 1)**: Key-Value Stores: Amazon DynamoDB, Key-Value Stores (in-memory) : Redis ColumnOriented Store: Google BigTable , Apache Cassandra - Hbase.

**NOSQL DATABASES (PART 2)**: Document Oriented Stores – MongoDB - Apache CouchDB - Graph databases: Neo4J –Orient DB.

**DATABASE INTEGRATION**: Data warehousing, Virtual Data Integration - Schema directed data integration - Schema mapping and information preservation.

**Tutorial Practices**:
1. Creating and querying object relational data base
2. Implementing of spatial database and spatial data queries.
3. Distribution using Map-Reduce on Big Data (Hadoop)
4. Data Integration from heterogeneous Databases.
5. Implementation of No-SQL databases : DynamoDB, MongoDB, HBASE, Neo4J.
TEXT BOOKS:

REFERENCES:

20SA64 CALCULUS OF VARIATIONS AND TRANSFORMS 3 2 0 4

Prerequisites:
20SA12 - Real Analysis,  
20SA13 - Differential Equations.

INTEGRAL EQUATIONS: Introduction - Linear integral equation of the first and second kind of Fredholm and Volterra type - Solutions with separable kernels – Eigenvalues – Eigenfunctions - Resolvent kernel – Construction of Green’s function for BVP. (9 + 6)


Total L : 45 + T: 30 = 75

TEXT BOOKS:

REFERENCES:

20SA65 CLASSICAL MECHANICS 3 2 0 4

Prerequisites:
20SA12 - Real Analysis,  
20SA13 - Differential Equations.

THE MECHANICAL SYSTEMS: Introductions, basic properties Generalized coordinates- Constraints - Virtual work - Energy and momentum. (9 + 6)

LAGRANGE’S EQUATIONS: Introduction to Lagrange’s equations, Derivation of Lagrange’s equations - Examples - Integrals of the motion. (10 + 7)

HAMILTON’S EQUATIONS: Introduction, Hamilton’s principles, Hamilton’s equations – Other variational principles. (10 + 7)

HAMILTON – JACOBI THEORY: Hamilton’s principal function - The Hamilton – Jacobi equation - Separability. (8 + 5)
**CANONICAL TRANSFORMATIONS:** Differential forms and generating functions - Special transformations - Lagrange and Poisson brackets

(8 +5)

**TEXT BOOKS:**

**REFERENCES:**

**20SA66 COMPUTAIONAL FINANCE**

3 2 0 4

**Prerequisites:**
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.


**MATHEMATICAL PRELIMINARIES:** Univariate distributions - quantiles of a distribution, Value-at-Risk – Bivariate distributions - Covariance, correlation, autocorrelation, linear combinations of random variables - Time series analysis: Covariance stationarity, autocorrelations, MA(1) and AR(1) models – Descriptive statistics - Stochastic calculus Martingales and Brownian motion.

**PORTFOLIO THEORY** - Introduction - Review of constrained optimization methods, Markowitz algorithm, Markowitz Algorithm using the solver and matrix algebra – Markowitz algorithm with no short sales constraints-Portfolio risk budgeting – Statistical analysis of efficient portfolios.


**THE CAPITAL ASSET PRICING (CAP) AND RISK BUDGETING** : Mean variance portfolio theory – Asset returns Variance as a risk measure - The one and two fund theorems – The capital market line – CAP as a pricing formula Systematic and unsystematic risk – Euler’s theorem – Asset contributions to volatility –Beta as a measure of portfolio risk-limitations.

**Total** L : 45 + T: 30 = 75

**Tutorial Practices:**
1. Obtaining financial data, computing returns, plotting and basic analysis
2. Working with time series data
3. Linear time series modeling and forecasting
4. Modeling volatility: Volatility forecasting for risk management
5. Portfolio optimization: Mean-variance model
6. Tangency portfolio and Capital Market Line
7. Asset Pricing model: Capital Asset Pricing Model, Beta estimation
8. Estimating the Term Structure of Interest Rates

**TEXT BOOKS:**

**REFERENCES:**

**20SA67 DATA MINING**

3 2 0 4

**Prerequisites:**
20SA14 - Probability, Stochastic Processes and Statistics.
INTRODUCTION: Data mining, kinds of data, kinds of patterns, major issues in data mining; Data objects and attribute types, measuring data similarity and dissimilarity.

DATA PREPROCESSING: Data pre-processing, data cleaning, data integration, data reduction.

MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS: Basic concepts, frequent item set mining methods, apriori algorithm, FP tree, pattern evaluation methods.

CLASSIFICATION: Basic concepts, decision tree induction, Bayes classification methods, model evaluation and selection, metrics for evaluating classifier performance, Holdout methods and Random sub sampling, Cross-validation and ROC Curves, Techniques to improve classification accuracy, Bagging, Boosting and AdaBoost.


TRENDS IN DATA MINING: Mining distributed heterogeneous and legacy databases, Multimedia data mining, Data mining and the World Wide Web, Security and Privacy issues for data mining.

Case Studies:
- Text mining: extracting attributes (keywords), Bayesian approach to classifying text
- Web mining: classifying web pages, extracting knowledge from the web
- Graph Mining: Sub-structure matching

Tutorial Practices:
1. Implementation of data mining techniques using WEKA.
2. Implementation of Association rule mining using Apriori algorithm and FP Growth algorithm
3. Classification rules using Decision Tree classifier, Ensemble of Classifiers.
4. Implementation of clustering algorithms
5. Case studies using R programming.

TEXT BOOKS:
1. Jiawei Han, Micheline Kamber and Jian Pei, ‘Data Mining – Concepts and Techniques’, Reed Elsevier, 2012.

REFERENCES:

20SA68 DESIGN AND ANALYSIS OF ALGORITHMS

Prerequisites:
20SA15 - Discrete Mathematics,
20SA24 - Data Structures.


SORTING ALGORITHMS: Insertion sort- Selection sort- Heap sort- Radix sort-time complexity analysis.

DIVIDE AND CONQUER: Method – examples – Merge sort, Quick sort, Strassen’s matrix multiplication, Closest Pair.

GREEDY METHOD: Optimization problems – method – examples – Minimum cost spanning tree (Kruskal’s and Prim’s algorithms), Topological sorting, Huffman coding, Fractional knapsack.

DYNAMIC PROGRAMMING: Method – examples – 0/1 Knapsack-All pairs shortest path problem – Traveling salesman problem.

NETWORK FLOW: Flows and Cuts-Max flow mincut theorem-Ford Fulkerson’s Algorithm


BRANCH & BOUND: Method – Example – 0/1 knapsack-Traveling salesman problem

Tutorial Practices:
1. Implementation of the following problems:
   1. Divide and Conquer versions of Merge sort, Quick sort, binary search and closest pair
   2. Greedy method implementation of Topological sort, Minimum cost spanning tree.
   3. Dynamic Programming implementation of Traveling Salesperson problem.
   4. Eight queen's problem backtracking algorithm.
   5. Knapsack using branch and bound algorithm

TEXT BOOKS:

REFERENCES:

20SA69 DIGITAL IMAGE PROCESSING AND COMPUTER VISION

Prerequisites:
20SA24 - Data Structures.


EDGE DETECTION: The Purpose of Edge Detection, Traditional Approaches and Theory, Edge Models, Comparison of Two Optimal Edge Detectors, Color Edges.

DIGITAL MORPHOLOGY: Connectedness, Binary Operations, Dilation and Erosion, Opening and Closing, Grey-Level Morphology, Color Morphology.


IMAGE ANALYSIS AND COMPUTER VISION: Feature Extraction - color, texture and shape features, Dimensionality Reduction, Clustering and Classification.

Tutorial Practices:
1. Basic image processing techniques like sampling and quantization
2. Implementation of Image segmentation and edge detection.
4. Implementation of 2-D DFT and DCT.
5. Implementation of feature extraction.
6. Implementation of image filtering methods in spatial and frequency domain.
8. Implementation of image classification and clustering.
9. Developing simple image analysis applications.

TEXT BOOKS:

REFERENCES:
**20SA70 EPIDEMIC MODELS**

**Prerequisites:**
20SA13 – Differential Equations,
20SA14 - Probability, Stochastic Processes and Statistics

**BASICS OF EPIDEMICS:** The epidemic in a closed population – Initial growth-the final size. Heterogeneity: Differences in infectivity, differences in infectivity and susceptibility.

**STRUCTURED POPULATIONS:** The concept of state-i-states, p-states, recapitulation and problem formulation

**THE BASIC REPRODUCTION RATIO:** The definition of $R_0$, general h-state, on conditions that simplify the computation of $R_0$, sub models for the kernel, extended example, pair formulation models. Partially vaccinated populations, the intrinsic growth rate $r$, some generalities, separable mixing.

**MACROPARASITES:** Introduction, counting parasite load, the calculation of $R_0$ for life cycles, seasonality and $R_{in}$, a pathological mode.

**CONTACT:** Introduction, Contact duration, consistency conditions, effects of subdivision, network models.

**TEXT BOOKS:**

**REFERENCES:**

**20SA71 GAME THEORY**

**Prerequisites:**
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

**INTRODUCTION:** Basic concepts -Theory of rational choice – Interacting decision makers

**STRATEGIC GAMES AND NASHEQUILIBRIUM:** Strategic games: Examples –Nash equilibrium: concept and examples -Best response – Dominated actions –Symmetric games and symmetric equilibria- Illustrations: Cournot’s and Bertrand’s models of duopoly,Electoral competition, War of Attrition , Auctions, Accident Laws.

**MIXED STRATEGY NASHEQUILIBRIUM:** Introduction, Strategic games with randomization- Mixed strategy Nash equilibrium: concept and examples - Dominated Actions -Formation of Players' beliefs - Illustrations: Expert diagnosis, Reporting a crime.

**EXTENSIVE GAMES WITH PERFECT INFORMATION:** Strategies and outcomes – Nash equilibrium – Sub game perfect equilibrium –Backward induction - Illustrations: Stackelberg’s model of duopoly, Buying votes, Ultimatum game.

**GAMES WITH IMPERFECT INFORMATION:** Bayesian games – Examples – Strategic information – Transmission – Agenda Control with imperfect Information – Signaling games - Education as a signal of ability.

**REPEATED GAMES:** Nash equilibrium in repeated games, finitely and infinitely repeated Prisoner's Dilemma - Sub game – Perfect equilibria and the one – deviation – Property – General results – Finitely replaced games – Variation on a theme: Imperfect observability.

**BARGAINING:** Rubinstein Bargaining Model with Alternating Offers -Nash Bargaining Solution- Relation of Axiomatic and Strategic Model- Illustration: Trade in market.

**AUCTION AND MECHANISM DESIGN:** introduction- The Vickery auction- Sponsored Search auction- Social Choice theory- VCG mechanism.

**Total**

**L : 45 + T: 30 = 75**
TEXT BOOKS:

REFERENCES:

20SA72 GEOMETRY OF LOCALLY FINITE SPACES

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

AXIOMATIC APPROACH TO DIGITAL TOPOLOGY: Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms. (8 + 5)

ABSTRACT CELL Complexes: Topology of complexes, Cartesian complexes and combinatorial coordinates, AC complexes compared with other Locally Finite Spaces. (10 + 7)

COMBINATORIAL HOMEOMORPHISM: Definition of combinatorial homeomorphism, balls and spheres, generalized boundary and boundary of space, orientation of AC complexes, combinatorial manifolds, block complexes, consistency of the (m,n)-adjacencies. (10 + 7)

MAPPINGS AMONG LOCALLY FINITE SPACES: Connected – Preserving Mappings (CPM), the combinatorial homeomorphism, properties of manifolds and block complexes. (8 + 5)

HOMOLOGY: Homology of groups, matrix reduction, relative homology, exact sequences, co-homology. (9 + 6)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

REFERENCES:

20SA73 INFORMATION RETRIEVAL AND WEBSEARCH

Prerequisites:
20SA11 – Contemporary Algebra,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA24 – Data structures.

INTRODUCTION: Overview of IR Systems - Historical Perspectives - Goals of IR - The impact of the web on IR - The role of artificial intelligence (AI) in IR. (3)

TEXT REPRESENTATION: Statistical Characteristics of Text: Zipf's law; Porter stemmer; morphology; index term selection; using thesauri. Basic Tokenizing, Indexing: Simple tokenizing, stop-word removal, and stemming; inverted indices; Data Structure and File Organization for IR - efficient processing with sparse vectors. (6)


QUERY PROCESSING: Query Operations and Languages- Query expansion; Experimental Evaluation of IR: Performance metrics: recall, precision, and F-measure. (5)
TEXT CATEGORIZATION AND CLUSTERING: Categorization: Rocchio; Naive Bayes, kNN; Clustering: Agglomerative clustering; k-means; Expectation Maximization (EM); Dimension Reduction: LSI, PCA. (6)

INFORMATION FILTERING TECHNIQUES: introduction to Information Filtering, Relevance Feedback - Applications of Information Filtering: RECOMMENDER SYSTEMS: Collaborative filtering and Content-Based recommendation of documents and products. (6)

WEB SEARCH: IR Systems and the WWW - Search Engines: Spidering, Meta Crawlers; Link analysis: Hubs and Authorities, Google PageRank, Duplicate Detection, (5)

INFORMATION EXTRACTION AND INTEGRATION: Extracting data from text; Basic Techniques: Named Entity Recognition, Co-reference Resolution, Relation Extraction, Event Extraction; Extracting and Integrating specialized information on the Web, Web Mining and Its Applications. (6)

Total L : 45 + T : 30 = 75

Tutorial Practices:
1. Different retrieval models - Boolean, Vector space and Probability based retrieval.
2. Query refinement techniques
3. Evaluation of the retrieval algorithms.
4. Dimension Reduction techniques
5. Classification and Clustering techniques
6. Recommender systems- Collaborative and Content Based Filtering
7. Information Extraction techniques
8. Web based retrieval - Link based retrieval, combining content and link information.

TEXT BOOKS:

REFERENCES:

20SA74 MATHEMATICAL MODELING

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION TO MODELING: Modeling process, Overview of different kinds of model. (2)

EMPIRICAL MODELING WITH DATA FITTING: Error function, least squares method; fitting data with polynomials and Splines. (4)


PORTFOLIO MODELING AND ANALYSIS: Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM). (12)

DISCRETE-TIME FINANCE: Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives (5)

MODELING WITH BIOINFORMATICS: Introduction, Biological data types, mode of collection, documentation and submission. Sequence alignment- Definition, significance, dot matrix method, dynamic programming- Global and local alignment tools, scoring matrices and gap penalties. Multiple sequence alignment; iterative methods. (12)

Total L : 45 + T :30 = 75
Tutorial Practices:
1. Least square method for fitting data
2. Modeling financial time series
3. ARIMA process
4. Markowitz model for portfolio modeling
5. Capital asset pricing models
6. CRR model
7. Sequence alignment by using dynamic programming technique
8. Multiple sequence alignment.

TEXT BOOKS:

REFERENCES:

20SA75 MOBILE APPLICATION AND DEVELOPMENT

Prerequisites:
20SA23 - Object oriented programming.

MOBILE AND WIRELESS DEVICES:
Introduction - Evolution of mobile communication generations - Challenges in mobile computing - Vertical and horizontal mobile applications.

CELLULAR CONCEPT:
Wireless transmission - Frequencies for radio transmission - Regulations - Signals, Antennas, Signal propagation, Path loss of radio signals, Additional signal propagation effects - Multi-path propagation - Cell Concept - Factors determining cell size and shape.

MOBILE APPLICATIONS ARCHITECTURE:
Smart Client - Smart Client Architecture - Messaging Architecture - The Model-View-Controller Model - Delegate Pattern - Building Smart Client Applications - Design, Development, implementation, testing and deployment phase - MVVM mobile architecture design.

MOBILE APPLICATION DEVELOPMENT:

DATABASE:
Files and database - SQLite on Android - Loading asynchronous data - Map API.

Tutorial Practices:
1. Android SDK installation and study
2. Defining Layouts
3. Single Activity Application, Application with multiple activities, using intents to Launch Activities
4. Application using GUI Widgets
5. Application with Notifications
6. Creating and Saving Shared Preferences and Retrieving Shared Preferences
7. Usage of SQLite Databases for storage
8. Working with Retrofit library in Android Applications
9. Android Automated Testing Frameworks

TEXT BOOKS:

REFERENCES:
20SA76 OPERATING SYSTEMS


PROCESS AND THREADS: Relationship between process and threads – Thread States – Thread Synchronization Types of Thread – Multithreading model.


VIRTUAL MEMORY MANAGEMENT: Need for Virtual Memory management – Demand Paging –Copy on write - Page Fault handling - Page replacement - Frame allocation- Threshing - working set model.


VIRTUALIZATION: Requirements for Virtualization - Type 1, Type 2 Hypervisors – Paravirtualization- Memory Virtualization - I/O Virtualization - Virtual machines on Multicore CPUs–Virtualization in Multiprocessor environment.

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Practicing UNIX Commands
2. Writing SHELL Scripts
3. Writing programs using UNIX System Calls
4. Process Creation and Execution
5. Thread Creation and Execution
6. Process / Thread Synchronization using semaphore
7. Developing Application using Inter Process communication (using sharedmemory, pipes or message queues)
8. Implementation of Memory Management Schemes

TEXT BOOKS:

REFERENCES:

20SA77 PREDICTIVE ANALYTICS

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics
DATA WRANGLING: DataIngest, Data Cleaning - Exploratory data analysis - Univariate data – Bivariate data, Multivariate data. (5 + 3)

LINEAR REGRESSION: Coefficient of determination, Significance test, Residual analysis, Confidence and Prediction intervals. (5 + 3)

MULTIPLE LINEAR REGRESSION: Coefficient of determination, Interpretation of regression coefficients, Categorical variables, heteroscedasticity, Multi-co linearity outliers, Auto regression and Transformation of variables, Regression, Model Building (10 + 7)

LOGISTIC AND MULTINOMIAL REGRESSION: Logistic function, Estimation of probability using Logistic regression, Variance, Wald Test, HosmerLemshow Test, Classification Table, Gini Co-efficient. (5 + 3)

DECISION TREES: introduction, CHI-Square Automatic Interaction Detectors (CHAID), Classification and Regression Tree(CART), Analysis of Unstructured data. (5 + 3)

FORECASTING: Moving average, Exponential Smoothing, Casual Models. (5 + 3)

TIME SERIES ANALYSIS: Moving Average Models, ARMA, ARIMA models , Multivariate Models. (5 + 3)

CASE STUDIES: Application of predictive analytics in retail, direct marketing, health care, financial services, insurance, supplychain, Social media analytics - Customer Analytics - Risk Analytics - Analytics for Retail and Ecommerce, etc- Working with data from different sources: spreadsheets, databases, and the cloud - Model Development- Model Validation. (5 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

REFERENCES:

20SA78 STATISTICAL LEARNING

Prerequisites:
20SA12 – Real Analysis,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA21 - Topology and Functional Analysis


LINEAR REGRESSION: Simple, Multiple, Other Considerations in the Regression Model – Resampling Methods Cross-Validation, Bootstrap– Linear Model Selection & Regularisation – Subset Selection, Shrinkage Methods – Ridge, Lasso, Dimension Reduction Methods, (8)

NON-LINEAR REGRESSION : Polynomial Estimators, Step Functions, Basis Functions, Regression Spline Smoothing Splines, Local Regression, Generalised Additive Models. (4)

LINEAR CLASSIFICATION: Review of Classification Models, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Comparison of Classification Methods. (6)

TREE BASED METHODS: Regression Trees, Classification Trees, Bagging, Random Forests, Boosting. (9)

SUPPORT VECTOR MACHINES: Maximal Margin Classifier – Support Vector Classifiers - Support Vector Machines – Non-linear DecisionBoundaries – SVMs with more than 2 classes. (4)

UNSUPERVISED LEARNING: Principal Components Analysis – Clustering Methods – K-Means Clustering,
Hierarchical Clustering

Tutorial Practices:
Solve the following problems using R
1. Simple Regression, Multiple Regression, Ridge Regression and Lasso Regression.
2. Non-linear Regression, Splines and Additive Models
3. Linear Classification,
4. Tree based methods
5. Support Vector machines
6. Clustering Methods

TEXT BOOKS:

REFERENCES:

20SA79 STOCHASTIC DIFFERENTIAL EQUATIONS

Prerequisites:
20SA13- Differential Equations,

MATHEMATICAL PRELIMINARIES: Probability spaces - Random variables - Stochastic processes – Brownian motion. (7 +4 )

ITO STOCHASTIC CALCULUS: Ito Integrals - Construction of its integrals - Properties (9 +6)

THE ITO FORMULA AND THE MARTINGALE REPRESENTATION THEOREM: The one-dimensional Ito formula - The multi-dimensional Ito formula – The Martingale representation theorem (9 + 6)

STOCHASTIC DIFFERENTIAL EQUATIONS: Construction of stochastic differential equations - an existence and uniqueness result- weak and strong solutions. (10 + 7)

METHOD OF SOLVING STOCHASTIC DIFFERENTIAL EQUATIONS: Linear stochastic differential equations - Reducible stochastic differential equations - Some explicitly solvable equations. (10 + 7)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

REFERENCES:

20SA80 TOPOLOGICAL DATA ANALYSIS

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

COMPLEXES: Topological spaces, Continuity, Connectedness, Surfaces, Homeomorphisms, Homotopy, Isotopy, Simplices, Simplicial Complex, Euler characteristics. (6+4)

HOMOLOGY :Simplicial Homology, Chain complexes, Cycles and boundaries, Homology groups and Betti numbers, The homology of a ball, Reduced homology, Induced maps, Matrix reduction: Euler-Poincaré formula, Boundary matrices, Smith normal forms, Reduction algorithm; Relative homology groups; Excision, Maps between vector spaces, Exact sequences: Chain complexes and chain maps, The snake or zig-zag, Connecting homomorphism, Mayer-Vietoris sequence, cohomology (12+8)
MORSE THEORY: Generic smooth functions, Morse functions, Morse lemma, Gradient vector field on a manifold, Attaching cells, Transversality, Integral lines, Stable and unstable manifolds, Morse-Smale functions, Morse-Smale complexes, Morse inequalities, Floer homology, Relation between Morse theory and Homology. (10+7)

PERSISTENT HOMOLOGY: The elder rule, Filtrations, Persistence, diagrams, Matrix reduction, Pairing lemma, Sparse matrix representation, Extended persistence, Spectral sequence, Stability, Bottleneck distance, Tame functions, Wasserstein distance, Length and total curvature of a curve using stability, Bipartite graph matching for computing bottleneck distance. (10+7)

DATA-STRUCTURES: Piecewise-linear functions, Scalar data analysis: Contour tree and Reeb graph, Vector data analysis. (7+4)

TEXT BOOKS:

REFERENCES: