REVISED SYLLABUS

2019-2020

M. TECH.

(COMPUTATIONAL MATHEMATICS)

DEPARTMENT OF APPLIED SCIENCES AND HUMANITIES
FACULTY OF ENGINEERING AND TECHNOLOGY
JAMIA MILLIA ISLAMIA, NEW DELHI-110025.

Introduction:

The field of computer simulation is of great importance in high-tech industry as well as and scientific and technological research. Familiar examples are virtual processing, climate studies, advanced materials, data structures, machine learning and big data analytics. Thus, computational science and engineering promote appropriate technology as well scientific advancement, helpful in engineering design. Activities involved are mathematical modeling, numerical analysis, computer algorithms, high-speed computing and visualization. The remarkable development in large scale computing in recent decades has transformed computational science and technology into an indispensible tool. It complement theory and lab experimentations, leading to new insights. Computational Mathematics is primarily concerned with mathematical foundations of computational science and technology.

Career Possibilities

M.Tech. program in computational mathematics is designed to meet the needs of sophisticated users; specially in the context of scientific investigations and technological innovation. Computational mathematics combines mathematics with computer science to produce useful techniques. The syllabus would cover relevant areas which are in demand. The program is comprehensive and would (for instance) meet the needs of ISRO, DRDO,DOS,BARC, research bodies and industry. Graduates would participate in research & development as well as computational activities. Their training would equip them with computational techniques; suited to conditions in India. Our country needs talented scholars with strong background in theory, modeling and computation. The government organizations, industry, multinational companies may face shortage of trained Scientists and computing experts if such programs are not promoted. India may play a key role on the world science with its technical manpower trained in computational

methods and techniques. India is poised to become world leader Soft-computing Mathematics. The M.Tech. program would provide students with comprehensive theoretical knowledge and impart practical training; with focus on computer science, numerical computing and mathematical finance. This programme has been introduced due to motivate youth towards sophisticated mathematics needed for modern scientific investigations and technological progress. The program would strive to equip students with comprehensive theoretical background. Graduates of M.Tech. programme in Computational Mathematics will acquire skills in applied mathematics; they would be well-prepared for advanced industrial positions or they may continue higher studies.

Objectives and outcomes:

The primary aim of M. Tech. program (Computational Mathematics) is to empower and enable students to acquire advanced knowledge and skills, they are expected to become leaders and efficient managers in computation sector. Specifically, the expected outcomes are:

1. Students will have a comprehensive understanding of the science and technology behind computation.
2. Students will understand the policy impact of fast and reliable computation.
3. Students will learn basic as well as advanced aspects of techniques needed in industry.
4. Students will develop research capability and communication skills to be effective leaders in applications of computation.

Prospects:

The M.Tech. program is designed to meet present and future needs of relevant mathematics in industry and research. The three components viz mathematics, computing and financial engineering need to be

blended together as integrated components to ensure relevance their mutual links are emphasized in the curriculum. Along with technical aspects of computing, the scope for development is pointed out. The program would be managed by a team of committed faculty members. They would impart skills and guide students in innovative ways.

If you are aiming for higher studies, and wish to explore deep insights available in mathematics and computing, the curriculum of this program offers a good opportunity. Skills and information can be put to good use in diverse research projects. Some relevant fields include data Mining, big data (map reduction), stochastic processes, machine learning, recommender systems and computer graphics. You may join applied Mathematics research or learn advanced Computer Science.

Placements:

On successful completion of the program, students would have job opportunities in software industry, financial institutions and government organizations. The employment possibilities include job in Consulting Engineering firms, Pharmaceutical Industry, Telecom industry, Banks Insurance companies.

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EFFECTIVE FROM THE CURRENT BATCH 2019-2020

M.TECH. COMPUTATIONAL MATHEMATICS (SELF-FINANCE)
I-SEMESTER

FIRST SEMESTER

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
THEORY									
01	CM-101	Computational Methods for Differential Equations	4	4	-	-	40	60	100
02	CM-102	Discrete Mathematics with Applications	4	4	-	-	40	60	100
03	CM-103	Computer Programming(R & Python)	4	4	-	-	40	60	100
04	CM-104	Database Management System(DBMS)	4	4	-	-	40	60	100
05	CM-105	Elective-I Operating Systems	4	4	-	-	40	60	100
06	CM-106	Lab–I (Computer Programming Lab using Python)	2	-	2	-	30	20	50
07	CM-107	Lab--II (ORACLE/Mysql Lab)	2	-	2	-	30	20	50
TOTAL CREDITS:24								**TOTAL MARKS:600**	

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M.TECH. COMPUTATIONAL MATHEMATICS (SELF-FINANCE)
II-SEMESTER

SECOND SEMESTER

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
THEORY									
01	CM-201	Mathematical Statistics and Stochastic Processes	4	4	-	-	40	60	100
02	CM-202	Computer based Numerical Techniques	4	4	-	-	40	60	100
03	CM-203	Data Structures and Algorithms	4	4	-	-	40	60	100
04	CM-204	Data Warehouse and Data Mining	4	4	-	-	40	60	100
05	CM-205	Elective-II Fuzzy Mathematics & Fuzzy Logic	4	4	-	-	40	60	100
06	CM-206	Lab–III (Numerical Techniques Lab)	2	-	2	-	30	20	50
07	CM-207	Lab--IV (Data Structures Lab)	2	-	2	-	30	20	50
TOTAL CREDITS:24								**TOTAL MARKS:600**	

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M.TECH. COMPUTATIONAL MATHEMATICS (SELF-FINANCE)
III-SEMESTER

THIRD SEMESTER

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
THEORY									
01	CM-301	Computer Network & Security	4	4	-	-	40	60	100
02	CM-302	Neural Networks & Optimization Techniques	4	4	-	-	40	60	100
03	CM-303	Big Data Analytics	4	4	-	-	40	60	100
04	CM-304	Minor Project/Machine Learning	4	-	-	-	-	100	100
05	CM-305	LAB-V (Big Data Analytics Lab)	2	2			30	20	50
06	CM-306	LAB-VI (Machine Learning Lab)	2	2			30	20	50
TOTAL CREDITS:20								**TOTAL MARKS:500**	

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M.TECH. COMPUTATIONAL MATHEMATICS (SELF-FINANCE)
IV-SEMESTER

FOURTH SEMESTER

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
THEORY									
01	CM-401	Project Work	12	-	-	-	-	300	300
TOTAL CREDITS:12								**TOTAL MARKS:300**	

Detailed Syllabus

I Semester

CM 101: Computational Methods for Differential Equations
CM 102: Discrete Mathematics with Applications
CM 103: Computer Programming (R & Python)
CM 104: Database Management System
CM 105: Elective-I (Operating Systems, Computer Architecture, Mathematical Finance)
CM 106: Lab-I (Computer Programming Lab using Python)
CM 107: Lab -II (ORACLE/ mysql Lab)

CM 101:Computational Methods for Differential Equations

Unit-1 Existence & uniqueness theorem; General theory of homogenous and non-homogenous differential equations with constant and variable coefficients; Method of variation of parameters, method of undetermined coefficients and the formula for particular integral in terms of wronskian; Solution of simultaneous differential equations.

Unit-2 Series solution for second order linear differential equations near an ordinary point; Singularity and the solution of differential equation in the neighborhood of regular singular point using method of Frobenious; Solution of Legendre, Bessel, Hypergeometric, Hermite and Lagurre differential equation.

Unit-3 Solution of partial differential equations using Lagrange's method of undetermined multipliers, Charpit's method; Complete solution of homogeneous and non-homogeneous L.P.D.E. of higher order with constant and variable coefficients. Formulation of Heat conduction equation and its solution by variable separation method, Steady state condition and the solution of heat conduction problem with non-zero end conditions. Formation of wave equation and their solution.

Unit-4 Linear homogeneous Boundary Value Problems, Eigen values and Eigen functions, Sturm-Liouville Boundary Value Problems, Non-homogeneous Boundary Value Problems, Non-homogeneous heat conduction problems.

Unit-5 Green's functions and the solution of Boundary Value Problems in terms of Green's functions, Concept of stability, asymptotic stability and instability of a solution of the autonomous system $dx/dt = F(x,y), dy/dt = G(x,y)$.

Books Recommended

1. Earl A. Coddington, An Introduction to Ordinary Differential Equation, Dover Publications, INC., 2012.
2. Boyce and Diprime, Elementary Differential Equations and Boundary Value Problems, Wiley, 2008.
3. H. F. Weinberger, A First Course in Partial Differential Equations: with Complex Variables and Transform Methods (Dover Books on Mathematics), Dover Publications, 1995.
4. M. D. Raisinghania, Advanced Differential Equations, S. Chand Publications, 2008.

CM 102: Discrete Mathematics with Applications

Unit 1. Introduction to the theory of sets,combination of sets, power sets, finite and infinite sets, principle of inclusion and exclusion,Relations and Functions, Equivalence Relations, Partial Order, Propositional Calculus.

Unit 2. Linear recurrence relations with constant coefficients (homogeneous case); discussion of all the three sub-cases. Linear recurrence relations with constant coefficients (non-homogeneous case); discussion of several special cases to obtain particular solutions. Solution of linear recurrence relations using generating functions

Unit 3. Lattices and Boolean algebra, Boolean Functions, Connonical Form (Disjunctive NormalForm) of a Boolean function, Karnaugh Maps.

Unit 4. Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, ConnectedGraphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.

Unit 5. Linear codes, Hamming Code, Generator and parity check matrix, Hamming distancestandard array and Syndrome decoding, introduction to cyclic codes.

Books Recommended

1. K.A. Ross, Charles R.W. Wright, Discrete Mathematics, 5th edition, PHI, 2002.
2. Bernard Kolman, Robert C. Busby, Discrete Mathematical Structure for Computer Sciences, Prentice Hall of India, 1987.
3. F.J. Mac. Williams, N. J. A. Sloane, Theory of Error Correcting Codes, North Holland Pub. Co., 1978.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 1979.
5. Liu C. L. , Elements of Discrete Mathematics, Second Edition, Mc Graw Hill 1985.
6. Mott J. L. , Kandel A. and Baker T. P., Discrete Mathematics for Computer Scientists and Mathematicians, Second Edition, Prentice Hall India, 1986.

CM 103: Computer Programming (R & Python)

UNIT 1 (PYTHON BASICS AND FLOW CONTROL)

Introduction to various scripting language. Benefits of scripting language over structured language. Introduction to Python GUI and Command line Interface. Using Editor. Variables and Data types in python. Input and output functions. Commenting and Indentation requirement. If conditions. if-else. Nested if-else conditions. For loop. While loop. Break and continue statements. Problem statement solving using the flow control. Algorithm designing using flow control

Unit 2. (PYTHON DATA STRUCTURES)

Accessing list and Tuples data values with loops. Working with various inbuilt methods of list and tuples. Comparison and concatenation in lists and tuples. Modifying list and tuple values. Creating user defined functions in python. Variable Argument passing with functions. Working with Python Dictionary data type. Modifying and analysing Dictionary entries. Creating Data base using Dictionary. Working with string. Accessing, modifying and manipulating strings. Working with string functions. Creating array in Numpy. Matrix operations in Numpy. Predefined method calling using Numpy. Matplotlib Module. 2D plotting using Matplotlib. subplot using matplotlib. ineractive plotting using matplotlib

Unit 3. (FILE HANDLING AND EXCEPTION HANDLING)

Types of exceptions**.** Using try and except**.** Using Final Statement**.** Raising Exceptions**.** Assert statement**.** except v/s else block**.** Opening the files with user defined permissions**.** Reading from files**.** Writing to files**.** Renaming and removing files**.** Binary mode for file operations

UNIT 4(GRAPHICAL USER INTERFACE WITH PYTHON)

GUI widgets. creating Layouts**.** pack method**.** Label, Button**.** Radiobutton**.** Checkbutton**.** Entry**.** Tkinter variables

Unit 5. (**OBJECT ORIENTED PROGRAMMING WITH PYTHON)**

Introduction to OOPs. The Class Statements. Constructor. Class Inheritance. Overriding,
Inherited Methods. Multiple Inheritance. Multilevel Inheritance. Method Overloading. Data Hiding.

Books Recommended

1. E. Balagrurusamy, Object Oriented Programming with C++, TMH, 2008.
2. Deitel and Deitel, C++ How to program, PHI, 4th Ed, 2003.
3. Robert Lafore, Object-oriented programming in C++, 4th Ed,Sams Publishing, 2002.

CM 104: Database Management System

Unit 1. Introduction to Database – Characteristics, Advantages & Disadvantages, Applications. Schemas and Instances. Difference Between Hierarchical, Network and Relational Model. Three Schema Architecture and Data Independence. Client Server Architecture for DBMS. Classification of DBMS.

Unit 2. Data Modeling and Functional Dependency: Data Model, Types, Data Modeling Using E-R Diagram, Entity Type, Entity Sets, Attribute and Keys, Weak Entity. Relational Model Concepts, Relational Database Schemas, Constraint Violations. Relational Algebra and Relational Calculus, Introduction to Tuple Relational Calculus and Domain Relational Calculus, Codd's Rule for Relational Database, Indexes and Hash Indexes.

Unit 3. Functional Dependency and Normalization: Design Guidelines for Relational Schemas, Functional Dependency, Normal Forms Based on Primary Keys. Definition of First Normal Form, Second Normal Form, Third Normal Form and BCNF.

Unit 4. Higher Normal Forms and Transaction Management: Multivalued Dependency and Fourth Normal Form, Join Dependency and Fifth Normal Form. Inclusion Dependency, Transaction Processing Concepts, Locks, Serializability and Concurrency Control, Database Security.

Unit 5. SQL: Table Creation, Deletion and Modification in SQL, Defining Constraints, Basic Structure of SQL for Data Extraction from Database, Insert, Delete & Update Statements in SQL, Views in SQL, Aggregate Functions , Nested Queries, Introduction of QBE. PL/SQL: Introduction of PL/SQL, Programming Constructs, Procedures, Functions, Exception handling, Cursors, Triggers and Packages.

Books Recommended:

1. Elmasri, Navathe, Fundamentals of Database Systems, Pearson Education, 2008.
2. Henry F. Korth, Abraham Silberschatz, S. Sudurshan,Database System Concepts, McGraw-Hill, 2005.
3. C. J. Date, An Introduction to Database Systems, Pearson, 2006.
4. Ramakrishna, Gehrke, Database Management Systems, Mcgraw-Hill, 2014.
5. S. K. Singh, Database Systems Concepts, Design and Applications, Pearson, 2011.
6. Jeffrey D. Ullman, Jennifer Widom, A first course in Database Systems, Pearson, 2014.

CM 105: Elective I (Operating Systems)

Unit 1. Introduction, Evolution of Operating System, Role and Functions of Operating Systems, Operating System Classification, Operating System Structure, Definition of Multiprogramming, Multitasking, Multiprocessing, Multi-user, Timesharing, Multithreading.

Unit 2. Process Overview, Process States and State Transitions, Levels of Schedulers and Scheduling Algorithms. Process Communication, Process Synchronization, Semaphores, Critical Section and Mutual Exclusion Problem, Classical Synchronization Problems, Multithreading. Introduction to Deadlock, Coffman's Conditions for deadlock, Deadlock Detection and Recovery, Deadlock Prevention, Deadlock Avoidance.

Unit 3. Classical Memory Management Techniques- Monoprogramming, Multiprogramming with fixed and variable partitions, Relocation & Protection, Swapping, Internal and External Fragmentation, Memory Compaction, Virtual Memory - Paging, Page Table, Page Replacement Policies, Segmentation, Thrashing.

Unit 4. File Concept, File Operations, Access Methods, Directory Structure, File-System Mounting, File Sharing, File-system Structure, File-System Implementation, Directory Implementation, Disk-block Allocation Methods, Free-Space Management. Disk structure, Disk Scheduling Algorithms- FCFS, SSTF, SCAN, C-SCAN, LOOK, C- LOOK.

Unit 5.UNIX and Linux operating systems as case studies.

Books Recommended:

1. A.S. Tanenbaum, Modern Operating Systems, Pearson Education, 3rd edition, 2015.
2. Silberschatz, P.B.Galvin and G. Gagne, Operating System Concepts, Wiley, 2009.
3. William Stallings, Operating Systems: Internals and Design Principles, PHI, 2009.
4. D.M. Dhamdhere, Operating Systems: A Concept Based Approach, Tata McGraw-Hill, 2007.
5. DeitelDeitelChoffnes, Operating Systems, Pearson, 2004.

CM 106: Lab-I (Computer Programming Lab using Python)
CM 107: Lab -II (ORACLE/ mysql Lab)

II Semester

CM 201: Mathematical Statistics and Stochastic Processes
CM 202: Computer based Numerical Techniques
CM 203: Data Structures and Algorithms
CM 204: Data Warehouse and Data Mining
CM 205: Elective-II (Artificial Intelligence)
CM 206: Lab-III (Numerical Techniques Lab)
CM 207: Lab-IV (Data Structures Lab)

CM 201: Mathematical Statistics and Stochastic Processes

Unit 1. Concept of probability; Random Variable and Distribution Function: discrete and continuous distributions, Moments and Moment Generating Functions; Binomial Distribution; Poisson Distribution; Negative Binomial Distribution; Geometric Distribution; Hypergeometric Distribution.

Unit 2. Uniform Distribution; ExponentialDistribution; GammaDistribution; NormalDistribution; LognormalDistribution; BetaDistribution.

Unit 3. Bivariate random variables: joint, marginal, conditional distribution; Statistical independence, product moment, correlation, regression, transformation of random variables, distribution of distribution function.

Unit 4. Simple random sampling with replacement and without replacement;Mean and variance of sample;Parameter and statistics;Order statistics and distribution of order statistics;Fundamental sampling distribution from normal population viz. χ^2 , t, f and Z (central).

Unit 5. Introduction to Stochastic Processes (SPs): Definition and examples of SPs; Definition and examples of Markov Chains (MCs): transition probability matrix, Chapman-Kolmogorov equations; calculation of n-step transition probabilities; limiting probabilities;Classification of states;Ergodicity;Stationary Distribution, transient MC; random walk and gambler's ruin problem, applications.Kolmogorov- Feller differential equations.

Books Recommended:

1. Miller, I. and Miller, M., "Freund's Mathematical Statistics with Applications", Prentice Hall PTR ,7th Ed. 2006.
2. Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. 2006.
3. Rohatgi, V. K. and Md. Ehsanes Saleh, A. K., "An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition. 2000.
4. Papoulis, A., Pillai, S.U., Probability, "Random Variables and Stochastic Processes", Tata McGraw-Hill, 4th Ed. 2002.
5. J. Medhi,Stochastic Processes, 3rd Edition, New AgeInternational, 2009.

CM 202: Computer based Numerical Techniques.

Unit 1. Roots of non-linear equations: Bisection method, Regula-Falsi method, Iterative method, Newton-Raphson Method, Graeffe's Root Squaring Method; Rate of convergence and error analysis of the method; Newton-Raphson method for solution of a pair of non-linear equations.

Unit 2. Solution of system of linear equations: (i) Direct methods: Gauss Elimination Method without Pivoting and with Pivoting, LU-decomposition method; Ill conditioned linear system; (ii) Iterative Methods: Jacobi and Gauss-Seidel methods, Curve fitting using method of least squares.

Unit 3. Finite difference operator and their relationships; Difference tables; Newton, Bessel and Stirling's interpolation formulae; Divided differences; Lagrange interpolation and Newton's divided difference interpolation.

Unit 4. Numerical differentiation: first and second order derivatives by various interpolation formulae; Numerical integration: Trapezoidal, Simpsons 1/3 and 3/8 rules, Booles Rule, Weddle Rule, Radau Rule; Errors in quadrature formulae; Gauss Legendre 2-points and 3-points Formulae; Numerical Integration and Double Integration using Romberg's Rule.

Unit 5. Solution of simultaneous, first and second order ordinary differential equations: Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methods and Milne's method.

Books Recommended:

1. Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley. 2002.
2. Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi. 2000.
3. Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGrawHill Publisher 1982.
4. Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication. 1998.

CM 203: Data Structures and Algorithms

Unit 1. Introduction to Data Structures: Data Types; Abstract Data Type(ADT) and Data Structures; Array as an ADT; Sparse Matrices: Representation and Transpose, Addition of Sparse Matrices; Introduction to Algorithm Design Paradigms, Motivation, Concepts of Algorithmic, Efficiency, Run-Time Analysis of Algorithms, Order Notation – Big O, Theta and Omega Notations.

Unit 2. Sorting and Searching Techniques: Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Linear Time Sorting: Bucket Sort, Radix Sort and Counting Sort, Searching Techniques: Sequential Search, Binary Search, Multiplication of Large Integers and Strassen's Matrix Multiplication.

Unit 3. Single and Doubly Linked List; Static and DynamicRepresentation of Linked List; Operations on Linked List - Creating, Traversing, Insertion,Deletion, Copy, Merging; Introduction to Stacks; Array Representation of Stack; Linkedrepresentation of Stack; Operations on Stacks; Applications of Stack – Infix, Prefix and PostfixExpressionsand their Conversion, Recursive Functions Implementations, Introduction toQueues; Array Representation of Queue; Linked Representation of Queue; Heaps and Priority Queues; Applications of Queue.

Unit 4. Basic concepts of Tree; Binary trees; Properties of Binary Trees;Representation of Binary Trees; Operations onBinary Tree, Binary Search Tree (BST), Operations in BST: Insertion, Deletion, Traversing; Ordered Binary Trees; AVL Trees; B-Trees; B+ Trees; Binomial Heaps; Red-Black Trees.

Unit 5. Algorithm Design Strategies: Divide-and-Conquer Approach, Structure of Divide-and-Conquer Algorithms, Analysis of Divide-and-Conquer Algorithms; Greedy Technique - Overall View of Greedy Paradigm, Prim's Algorithm, Kruskal's algorithm, Dijkstra's Algorithm, Form of Dynamic Programming Algorithms, Differences between Dynamic Programming and Divide-and-Conquer Approach, Matrix Chain Multiplication, Longest Common Subsequence Problem, Warshall's and Floyd's Algorithms. Travelling Sales Person Problem,

Books Recommended:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, 2nd Ed.,Prentice-Hall of India, 2007.
2. A.V. Aho and J. E. Hopcroft, Data Structures and Algorithms, Addison-Wesley, 1983.
3. S. Sahni, Data Structures, Algorithms and Applications in C++, 2nd Ed., Universities Press, 2005.
4. D. Samanta, Classic Data Structures, 2nd Ed, PHI, 2002.

CM 204: Data Warehouse and Data Mining

Unit 1. Introduction to Data Warehousing;Evolution of Decision Support Systems; Modeling a Data Warehouse;Granularity in the Data Warehouse; Data Warehouse Life Cycle;Building a Data Warehouse; Data Warehousing Components; Data Warehousing Architecture.

Unit 2. Introduction to Data Mining: KDD (Knowledge Discover from Databases) Process and Data Mining; KDD Steps; Types of Data for Data Mining, Data Mining Functionalities, Classification of Data Mining Systems; Data Mining Task Primitives; Major Issues in Data Mining. Introduction to Data Preprocessing, Descriptive Data Summarization: Measuring and Central Tendency and Dispersion of Data; Visualization of Descriptive Data Summaries; Data Cleaning: Handling Missing Values, Filtering Noisy Data – Binning Method; Data Integration; Data Transformation: Smoothing, Aggregation, Generalization, Normalization and Feature Selection; Data Reduction; Data Discretization and Concept Hierarchy Generation.

Unit 3. Association Rule Mining: Market basket Analysis; Frequent Itemsets, Closed Itemsets, and Association Rules; Support and Confidence; Apriori Algorithm for Mining Frequent Itemsets using Candidate Generation; Generating Association Rules from Frequent Itemsets; Improving the Efficiency of Apriori Algorithm; FP-Growth Algorithm for Mining Frequent Itemsets without Candidate Generation; Mining Closed Frequent Itemsets; Correlation Analysis.

Unit 4. Classification Rule Mining: Introduction to Classification and Prediction; Classification by Decision Induction; Attribute Selection Measures: Information Gain, Gain Ratio, and Gini Index; Tree Pruning; Bayesian Classification: Bayes' Theorem, Naïve Bayesian Classification, Bayesian Belief Networks; Classifier Accuracy Measures: Sensitivity, Specificity, Precision, and Accuracy; Predictor Error Measures; Accuracy Evaluation Methods: Holdout, Random Subsampling, Cross-validation, and Bootstrap; Accuracy Enhancement Methods: Bagging and Boosting.

Unit 5. Introduction to Clustering, Features Required for Clustering Algorithms, Data Types and Dissimilarity Measures in Cluster Analysis; Categorization of Clustering Methods; Partitioning-Based Clustering: k-means Algorithms, k-medoids algorithms (PAM, CLARA, CLARANS); Hierarchical Clustering: Agglomerative and Divisive Methods (AGNES, DIANA, BIRCH; Density-Based Clustering: DBSCAN.

Books Recommended:

1. J. Han & M. Kamber, Data Mining Concepts and Techniques, 2nd Ed., Morgan Kaufman, 2011.
2. Witten & E. Frank, Data Mining – Practical Machine Learning Tools and Techniques, Morgan Kaufman, 2011.
3. Michael Berry & Gordon Linoff, Data Mining Techniques, 3rd Edition, 2011.

CM 205: Elective-II (Artificial Intelligence)

Unit 1. Introduction: AI Problems, Foundation of AI and History of AI Intelligent Agents: Agents and Environments, The Concept of Rationality, The Nature of Environments, Structure of Agents, Problem Solving Agents and Problem Formulation.

Unit 2. Searching: Searching For Solutions, Uniformed Search Strategies – Breadth First Search, Depth First Search, Depth Limited Search, Iterative-Deepening Depth First Search Bi-Direction Search - Comparison. Search with Partial Information (Heuristic Search) Greedy Best First Search, A* Search, Memory Bounded Heuristic Search, Heuristic Functions. Local Search Algorithms: Hill Climbing, Simulated, Annealing Search, Local Beam Search, Genetical Algorithms. Constrain Satisfaction Problems: Backtracking Search for CSPS Local Search for Constraint Satisfaction Problems.

Unit 3. Knowledge Representation & Reasons Logical Agents: Knowledge – Based Agents, the Wumpus World, Logic, Propositional Logic, Resolution Patterns in ProposIonal Logic, Resolution, Forward & Backward. Chaining. First Order Logic. Inference in First Order Logic, Propositional Vs. First Order Inference, Unification & Lifts Forward Chaining, Backward Chaining, Resolution.

Unit 4. Planning: Classical Planning Problem, Language of Planning Problems, Expressiveness and Extension, Planning With State – Space Search, Forward States Spare Search, Backward States Space Search, Heuristics for Stats Space Search. Planning Search, Planning With State Space Search, Partial Order Planning Graphs.

Unit 5. Learning: Forms of Learning, Induction Learning, Learning Decision Tree, Statistical Learning Methods, Learning With Complex Data, Learning With Hidden Variables – The EM Algorithm, Instance Based Learning, Neural Networks.

Books Recommended:

1. Rajendra Akerkar, Introduction to Artificial Intelligence, PHI.
2. Stuart Russel, Peter Norvig, Artificial Intelligence – A Modern Approach. Second Edition, PHI/Pearson Education.
3. Patrick Henry Winston., Artificial Intelligence, 3rd Edition, Pearson Edition.
4. E.Rich and K.Knight, Artificial Intelligence , 2nd Edition, (TMH).
5. Ivan Bratka, PROLOG Programming for Artificial Intelligence, Third Edition – Pearson Education.

CM 206: Lab-III (Numerical Techniques Lab)
CM 207: Lab-IV (Data Structures Lab)

III SEMESTER

CM 301: Computer Network & Security
CM 302: Neural Networks & Optimization Techniques
CM 303: Big Data Analytics
CM 304: Machine Learning
CM 306: Lab-V (Big Data Analytics Lab)
CM 307: Lab –VI (Machine Learning Lab)

CM 301 Computer Network & Security

Unit 1. Modular Arithmetic; Euclidean and Extended Euclidean Algorithm; Prime Numbers; Fermat's and Euler's Theorem; Groups; Rings; Fields; Finite Fields; Polynomial Arithmetic; Testing For Primality; The Chinese Remainder Theorem; Discrete Logarithms; Introduction to Cryptography; Dimensions of Cryptography; Classical Cryptographic Techniques.

Unit 2. Data Encryption; Standard-Block; Cipher Principles-Block; Cipher Modes of Operation; Feistal Cipher Structure;Advanced Encryption Standard (AES);Simplifies DES; Double andTriple DES; Public Key Cryptography: Principles of Public Key Cryptosystems-The RSA Algorithm-Key Management – Diffie Hellman Key Exchange; Elliptic Curve Arithmetic; Elliptic Curve Cryptography.

Unit 3. Authentication Requirement; Functions; Message Authentication Code; Hash Functions; Security of Hash Functions And Macs; MD5 Message Digest Algorithm; Secure Hash Algorithm; Digital Signatures.

Unit 4. Authentication Applications;Key Distribution Techniques; Kerberos; X.509 Authentication Services; Internet Firewalls For Trusted System: Roles of Firewalls, Firewall Related Terminology, Types of Firewalls, Firewall Designs; SET for E-Commerce Transactions; Intruder; Intrusion Detection System; Virus and Related Threats; Countermeasures; Firewalls Design Principles: Trusted Systems; Practical Implementation of Cryptography and Security.

Unit 5. Threats in networks; Network Security Controls; Architecture; Encryption; Content Integrity; Strong Authentication; Access Controls; Wireless Security; Honeypots; Traffic flow security; Firewalls; Design andTypes of Firewalls; Personal Firewalls; IDS; Email Security.

Books Recommended:

1. William Stallings, Cryptography And Network Security Principles And Practice, 4th Edition, Pearson Education.
2. Wenbo Mao, Modern Cryptography: Theory and Practice, Prentice Hall PTR.
3. William Stallings, Network Security Essentials: Applications and Standards,. Prentice Hall.
4. Douglas R. Stinson, Cryptography: Theory and Practic, CRC press.

CM-302 Neural Networks & Optimization Techniques

Unit 1. Introduction to neurons, working of biological neurons, Artificial neuron, Brain vs Computer, Neural networks architectures, classifications and characteristics, Basic model of ANN: connections, weights, bias, and activation functions. McCulloch-Pitts Neuron, Threshold logic units, McCulloch-Pitts neuron as logic gates and memory elements.

Unit 2. Hebb neuron: training algorithm and applications, Linear separability, ANN Learning rules, Supervised learning: Perceptron, ADALINE, XOR problem, MADALINE. Multi-layer Neural networks, Back-propogation derivation & training algorithm. Working examples of BP algorithms for training Multi-layer neural networks.

Unit 3. Unsupervised learning Kohonen Self-organizing feature map, Feedback Networks: Hopfield Networks, storage and retrieval of information in Hopfield neural networks (HNN), Bidirectional associatve memory (BAM), Adaptive resonance theory (ART) neural networks etc. Working examples on HNN, BAM & ART, Some applications of ANNs.

Unit 4. Introduction to optimization: basics, classifications & charateristics, Linear programming: concepts, solving method, applications. Nonlinear programming: Concepts, solving methods, examples. Dynamic programming method. Traveling salesman problem, Transportation problem

Unit 5. Introduction to Genetic algorithm: working principle, encoding methods, fitness function, reproduction, Roulette Wheel, Tournament Selection, Rank Selection etc, cross-over and mutation operators, Applications of genetic algorithm, Recent optimization techniques

Books Recommended:

1. S Haykin, “Neural Networks: A Comprehensive Foundations” Pearson,
2. Rajasekaran & Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications”, PHI, 2011.
3. David E Goldberg, “Genetic Algorithm in Search, Optimization & Machine Learning”, Pearson, 2011.
4. N P Padhy & S P Simon, “Soft Computing with MATLAB Programming”, Oxford Publication, 2015.

CM 303: Big Data Analytics

Unit 1. Introduction – Big Data and its importance, Four Vs, Drivers for Big data, Introduction to Big data analytics, Big data applications. Algorithms using MapReduce, Matrix-Vector Multiplication by MapReduce.

Unit 2. Introduction to Apache Hadoop & Hadoop EcoSystem - Data handling in Hadoop, Data handling in MapReduce, Data Serialization.

Unit 3. Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., NameNode, Secondary NameNode, and DataNode, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering -Monitoring & Maintenance. Hadoop ecosystem components - Schedulers - Fair and Capacity, Hadoop 2.0 New Features NameNode High Availability, HDFS Federation, MRv1, MRv2, YARN, Running MRv1 in YARN.

Unit 4. Basic nomenclature - Analytics process model - Analytics model requirements - Types of data sources - Sampling - types of data elements - Visual Data Exploration and Exploratory Statistical Analysis - Missing Values - Outlier Detection and Treatment - Standardizing Data – Categorization - weights of evidence coding - Variable selection -Segmentation.

Unit 5. Predictive Analytics: Target Definition - Linear Regression - Logistic Regression - Decision Trees - Neural Networks - Support Vector machines - Ensemble Methods - Multiclass Classification Techniques-Evaluating Predictive Models. Descriptive Analytics: Association Rules - Sequence Rules - Segmentation. Survival Analysis: Survival Analysis Measurements - Parametric Survival Analysis.

Books Recommended:

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.
2. Chris Eaton, Dirk deroos et al. , “Understanding Big data ”, McGraw Hill, 2012.
3. Tom White, “HADOOP: The definitive Guide” , O Reilly 2012.
4. Vignesh Prajapati, “Big Data Analytics with R and Haoop”, Packet Publishing 2013.
5. Tom Plunkett, Brian Macdonald et al, “Oracle Big Data Handbook”, Oracle Press, 2014.
6. Jy Liebowitz, “Big Data and Business analytics”,CRC press, 2013.
7. Baesens, 2014, Analytics in a Big Data World: The Essential Guide to Data Science and Its applications, Wiley India Private Limited.
8. Michael Minelli, Michele Chambers, 2013, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today’s Businesses, Wiley CIO
9. Stephan Kudyba, 2014, Big Data, Mining and Analytics: Components of Strategic Decision Making, CRC Press.
10. Frank J. Ohlhorst, 2013, Big data Analytics: Turning Big Data into Big Money, Wiley and SAS Business Series.
11. Foster Provost, Tom Fawcett, 2013, Data Science for Business, SPD.

CM 304: Machine Learning

Unit 1. Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept LearningTask – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spacesand the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability– Linear Regression. .

Unit 2. Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

Unit 3. Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map .

Unit 4. Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

Unit 5. Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods. Model and Symbols- Bagging and Boosting, Multitask learning, Online learning and Sequence Prediction, Data Streams and Active Learning, Deep Learning, Reinforcement Learning.

Books Recommended:

1. Peter Flach: Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press, Edition 2012.
2. Hastie, Tibshirani, Friedman: Introduction to Statistical Machine Learning with Applications in R, Springer, 2nd Edition-2012.
3. ParagKulkarni : Reinforcement and Systematic Machine Learning for Decision Making, WileyIEEE Press, Edition July 2012.
4. EthemAlpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)‖, Third Edition, MIT Press, 2014.

CM 305: Lab-V(Big Data Analytics Lab)
CM-306: LAB-VI(Machine Learning Lab)

IV SEMESTER

CM 401 Project work