MTECH (CSE) CURRICULUM AND SYLLABUS

A two years fulltime semester based degree programme in

Computer Science and Engineering

Effective from Academic Session 2018-2019

Department of Computer Science and Engineering

Aliah University

MTech (CSE) Curriculum

Semester I

Code	Subject Name	L	T	P	Marks	Credit Points
CSE601	Mathematical Foundations of Computer Science	3	1	0	100	4
CSE603	Advances in Algorithms	3	1	0	100	4
CSE605	Elective-I	3	1	0	100	4
CSE607	Elective-II	3	1	0	100	4
CSE609	Elective-III	3	1	0	100	4
CSE691	Information Systems Lab-I	0	0	6	100	3

Elective-I, II, III

A. Advanced Software Engineering
B. Wireless Communication and Mobile Computing
C. Information and Coding Theory
D. Advanced Image Processing
E. Advanced Database System Concepts
F. Modeling and Simulation
G. VLSI System Design
H. CAD for VLSI
I. Fault Tolerant Systems
J. Cloud Computing
K. Wireless Sensor Network
L. Natural Language Processing

Semester II

Code	Subject Name	L	T	P	Marks	Credit Points
CSE602	Data Science	3	1	0	100	4
CSE604	Elective-IV	3	1	0	100	4
CSE606	Elective-V	3	1	0	100	4
CSE608	Elective-VI	3	1	0	100	4
CSE692	Information Systems Lab-II	0	0	6	100	3
CSE672	Interim Term Paper	0	0	3	100	2
CSE682	Seminar	0	0	3	100	2

Elective IV, V, VI

A. Network Security and Cryptography
B. Parallel Computing Techniques
C. Data Warehousing and Data Mining
D. Theory of Computing
E. Multimedia Technologies
F. Bioinformatics
G. Advanced Machine Learning
H. Internet of Things
I. Big Data Analytics

Semester III

Code	Subject Name	L	T	P	Marks	Credit Points
CSE701	Elective VII	3	1	0	100	4
CSE771	Dissertation-I	0	0	24	200	12

Elective VII

A. Selected Topics

Semester IV

Code	Subject Name	L	T	P	Marks	Credit Points
CSE772	Dissertation-II	0	0	32	300	16
CSE784	Comprehensive Viva-Voce	0	0	0	100	2

Semester I

Mathematical Foundations of Computer Science

Code: CSE601
Contacts: 3L+1T
Credits: 4

Module-1 (18 hours)

Mathematical Logic: Statements and notations, Connectives, Well-formed formulas, Truth Tables, tautology, equivalence implication, Normal forms, Compactness and resolution; Formal reducibility – natural deduction system and axiom system; Soundness and completeness.

Predicates: Predicative logic, Free & Bound variables, Rules of inference, Consistency, proof of contradiction, Automatic Theorem Proving**.**

Introduction to Predicate Calculus: Syntax of first order language; Semantics – structures and interpretation; Formal deductibility; First order theory, models of a first order theory (definition only), validity, soundness, completeness, compactness (statement only), outline of resolution principle.

Module-2 (12 hours)

Combinatorics: Basis of counting, Combinations & Permutations, with repetitions, Constrained repetitions, Binomial Coefficients, Multinomial theorem, principle of inclusion exclusion;

Recurrence relations – classification, summation method, extension to asymptotic solutions from solutions for subsequences; Linear homogeneous relations, characteristic root method, general solution for distinct and repeated roots, non-homogeneous relations and examples, generating functions and their application to linear homogeneous recurrence relations, non-linear recurrence relations, exponential generating functions, brief introduction to Polya theory of counting.

Module-3 (18 hours)

Graph Theory and Applications: Graphs and digraphs, complement, isomorphism, connectedness and reachability, adjacency matrix, Eulerian paths and circuits in graphs and digraphs, Hamiltonian paths and circuits in graphs and tournaments, trees; Minimum spanning tree, rooted trees and binary trees, planar graphs, Euler's formula, statement of Kuratowskey's theorem, dual of a planer graph, independence number and clique number, chromatic number, statement of Four-color theorem, dominating sets and covering sets.

Suggested Books and References:

1. J. L. Mott, A. Kandel and T. P. Baker: Discrete Mathematics for Computer Scientists, Reston, Virginia, 1983.
2. D. F. Stanat and D. E. McAllister: Discrete Mathematics in Computer Science, Prentice Hall, Englewood Cliffs, 1977.
3. C. L. Liu: Elements of Discrete Mathematics, 2nd ed., McGraw Hill, New Delhi, 1985.
4. R. A. Brualdi: Introductory Combinatorics, North-Holland, New York, 1977.
5. E. M. Reingold and J. Nievergelt, Combinatorial Algorithms: Theory and Practice, Prentice Hall, Englewood Cliffs, 1977.
6. J. A. Bondy and U. S. R. Murty: Graph Theory with Applications, Macmillan Press, London, 1976.

7. N. Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, Englewood Cliffs, 1974.
8. E. Mendelsohn: Introduction to Mathematical Logic, 2nd ed. Van-Nostrand, London, 1979.
9. L. Zhongwan: Mathematical Logic for Computer Science, World Scientific, Singapore, 1989.
10. F. S. Roberts: Applied Combinatorics, Prentice Hall, Englewood Cliffs, NJ, 1984.
11. L. Lewis and Papadimitriou: Elements of Theory of Computation (relevant chapter on Logic), Prentice Hall, New Jersey, 1981.

Advances in Algorithms

Code: CSE603
Contacts: 3L+1T
Credits: 4

Module-1 (06 hours) Design Paradigms: Overview:
Overview of Divide and Conquer, Greedy and Dynamic Programming strategies. Basic search and traversal techniques for graphs, Backtracking, Branch and Bound.

Module II (04 hours)
The Maximum Flow Problem and Ford-Fulkerson algorithm, The maximum cut problem flow and minimum

Module III (06 hours) String Matching:
Introduction to string-matching problem, Naive algorithm, Rabin Karp, Knuth Morris Pratt, Boyer-Moore algorithms and complexity analysis.

Module IV (06 hours) Theory of NP- Hard and NP-Complete Problems:
P, NP and NP-Complete complexity classes; A few NP-Completeness proofs; Other complexity classes.

Module V (12 hours) Approximation Algorithms:
Introduction, Combinatorial Optimization, approximation factor, PTAS, FPTAS, Approximation algorithms for vertex cover, set cover, TSP, knapsack, bin packing, subset-sum problem etc. Analysis of the expected time complexity of the algorithms.

Module VI (08 hours) Parallel Algorithms:
Introduction, Models, speedup and efficiency, Some basic techniques, Examples from graph theory, sorting, Parallel sorting networks. Parallel algorithms and their parallel time .and processors complexity.

Module VII (06 hours) Probabilistic Algorithms & Randomized Algorithms:
Numerical probabilistic algorithms, Las Vegas and Monte Carlo algorithms, Game-theoretic techniques, Applications on graph problems

Suggested Books and References:

1. Introduction to Algorithms: T.H. Cormen, C.E.Leiserson and R.L. Rivest
2. Fundamentals of Algorithmics: G.Brassard and P.Bratley
3. Approximation Algorithms: Vijay V.Vazirani
4. Randomized Algorithms: R. Motwani and P.Raghavan
5. Algorithmics: The spirit of computing: D.Harel

Elective I, II, III

Code: CSE605, CSE607, 609
Contacts: 3L+1
Credits: 4

A. Advanced Software Engineering

Module I (12 hours): Introduction

Introduction to Software Engineering, Software Project Management, Metrics and Measurement, Software Configuration management, Software risk management, Requirements Engineering, Software quality assurance, software reliability models. Introduction and Brief Overview - Software process, modeling and analysis, software architecture, software design. Software Modeling, Analysis, Testing - Analysis modeling and best practices, traditional practice diagrams such as DFDs and ERDs etc, Traditional Testing techniques – white box and black box testing.

Module II(12 hours): Design Methodologies

Software Design - Design best practices, design patterns, extreme programming, refactoring, design case studies, component technology, object oriented frameworks, distributed objects, object request brokers, case studies. Object oriented design, object oriented programming Formal specifications, Formal verification of programs, Jackson method for design, CASE tools and technology, Clean room method for software development, Information system design, Real-time software specification and design. Object-Oriented Software Engineering - Concept of OO Software – Design and Analysis, Overview of various UML diagrams and UML analysis modeling, analysis case studies, analysis tools, analysis patterns, OO software testing. Case study with complete examples.

Module III(12 hours): Role of architecture in software engineering

Software Architecture - Architectural styles, architectural patterns, analysis of architectures, formal descriptions of software architectures, architectural description languages and tools, scalability and interoperability issues, web application architectures, case studies. Enterprise architectures, Zachman's Framework, design Patterns, Architecture Description Languages, Product-Line architectures, Component Based Development.

Module IV(12 hours): Research & Seminar

Web Engineering, Clean room Engineering and other recent topics. Introduce Recent Publications on Software Engineering and more new research oriented topics, seminars, topics of current research which will focus on the state- of-the-art in various areas of Software Engineering.

Suggested Books and References:

1. P. Jalote, “An integrated approach to Software Engineering”, 2nd Edition, Narosa Publishing house.
2. S. L. Pfleeger, “Software Engineering”, Macmillan Publishing Company, 1987
3. Roger Pressman, “Software Engineering: A Practitioner approach”, 4th Edition, McGraw-Hill Publishing.
4. F. Buschmann, R. Meunier, H. Rohnert, P. Sommerland, and M. Stal, “Pattern Oriented Software Architecture, Volume 1”.
5. L. Bass, P. Clements, R. Katzman, “Ken Bass Software Architecture in Practice”
6. Reputed journals like IEEE Trans. on Software Engineering, ACM Trans. on Software Engineering and Methodology, etc.

B. Wireless Communication and Mobile Computing

Module I. Introduction to Mobile Communications and Computing (6 Hours)

Mobile Computing (MC): Introduction to MC, novel applications, limitations, and architecture. GSM: Mobile services, System architecture, Radio interface, Protocols, Localization and calling, Handover, Security, and New data services.

Module II. (Wireless) Medium Access Control (6 Hours)

Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

Module III. Mobile Network Layer (6 Hours)

Mobile IP (Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP).

Module IV. Mobile Transport Layer (6 Hours)

Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time-out freezing, Selective retransmission, Transaction oriented TCP.

Module V. Database Issues (6 Hours)

Hoarding techniques, caching invalidation mechanisms, client server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality of service issues.

Module VI. Data Dissemination (6 Hours)

Communications asymmetry, classification of new data delivery mechanisms, push based mechanisms, pull-based mechanisms, hybrid mechanisms, selective tuning (indexing) techniques.

Module VII. Mobile Ad hoc Networks (MANETs) (6 Hours)

Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs.

Module VIII. Protocols and Tools (6 Hours)
Wireless Application Protocol-WAP. (Introduction, protocol architecture, and treatment of protocols of all layers), Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) and J2ME.

Suggested Books and References:

1. Mobile Communications, Jochen Schiller by Addison-Wesley.
2. Wireless Communications & Networks, Second Edition, William Stallings by Pearson
3. Mobile Computing, Raj Kamal by Oxford Wireless networks, P. Nicopolitidis, M.S. Obaidat, G. I. Papadimitriou, A. S. Pomportsis by WILEY
4. Mobile Computing Theory and Practice-Kumkum Garg-Pearson
5. Lauren Darcey and Shane Conder, Android Wireless Application Development, Pearson Education, 2nd ed. (2011).
6. Mobile Computing: Technology, Applications and Service Creation, A. K Telukder and R. Yavagal, TMH
7. Android Application Development Black Book, Pradeep Kothari, dreamtech press.
8. Wireless and Mobile Networks, S. S. Manvi and M. S. Kakkasageri by WILEY

C. Information and Coding Theory

Module-1.Information Theory (8 Hours)
Information – Entropy, Information rate, classification of codes, Kraft McMillan inequality, Source coding theorem, Shannon-Fano coding, Huffman coding, Extended Huffman coding - Joint and conditional entropies, Mutual information - Discrete memory less channels – BSC, BEC – Channel capacity, Shannon limit.

Module-2.Coding Theory (20 Hours)
Linear Block Codes: Groups, Fields and Vector Space, Construction of Galois Fields of Prime Order , Syndrome Error Detection, Standard Array and Syndrome Decodin, Hamming Codes
Cyclic binary codes: BCH codes, generalized BCH code and decoding, optimum codes, concepts of non-cyclic codes.
Structure and Properties of Convolutional Codes: Convolutional Encoder Representation, Tree, Trellis, and State Diagram, Distance Properties of Convolutional Code, Punctured Convolutional Codes and Rate Compatible Schemes
Threshold decoding: Threshold decoding for block codes.
Decoding of Convolutional Codes: Maximum Likelihood Detection, The Viterbi Algorithm

Module-3 Combinatorial Designs (8 Hours)
Definitions of BIBD, Hadamard Designs, Latin Squares, Mutually Orthogonal Latin Squares, Orthogonal Arrays. Constructions of codes using designs: Example: Hadamard codes.

Module-4 Network Coding (12 Hours)
Fundamentals of Network Coding: Butterfly networks, graphs and networks; The max-flow min-cut theorem, the multi-source multicast problem, deterministic code design for network coding, randomized network coding application of network coding.

***Suggested Books and References*:**

1. J. A. Thomas and T. M. Cover: Elements of information theory, Wiley, 2006.

2. J. H. van Lint: Introduction to Coding Theory, Third Edition, Springer, 1998.
3. R. Bose, Information Theory, Coding and Cryptography, McGrawHill
4. F. J. MacWilliams and N.J. Sloane: Theory of Error Correcting Codes, Parts I and II, North-Holland, Amsterdam, 1977.
5. D. Stinson: Combinatorial Designs: Constructions and Analysis, Springer, 2003
6. P. J. Cameron and J. H. van Lint: Designs, Graphs, Codes and their Links, Cambridge University Press, 2010.
7. C. Fragouli and E. Soljanin: Network Coding Fundamentals, Now Publisher, 2007.
8. C. Fragouli, J. Le Boudec, J. Widmer: Network coding: An instant primer
9. M. Medard and A. Sprintson, (editors): Network Coding – Fundamentals and Applications, Academic Press, 2012.

D. Advanced Image Processing

Module I Digital Image Fundamentals (8 Hours)
Introduction, image definition and representation, neighbourhood, histogram; Image enhancement - noise models, image denoising using linear filters, order statistics based filters, image smoothing and sharpening, image super-resolution; Frequency domain concepts, filtering, DFT, DCT, Wavelet, etc.

Module II Image Segmentation (8 Hours)
Point/edge detection, kernel, operators, global and local thresholding, multi-level thresholding, region growing, split/merge techniques, component labelling, etc.

Module III Image Features (10 Hours)
Harris corner detector, Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Hough Transform, Medial axis transform; shape properties, textural features – moments, gray level co-occurrence matrix, structural features, Fourier descriptor, polygonal approximation

Module IV Morphological Operations (6 Hours)
Basic concepts, erosion, dilation, opening, closing, boundary extraction, region, filling, convex hull, thinning and thickening, skeletonization, etc.; Advanced applications like biomedical image processing, digital watermarking, etc.

Module V Color Image Processing and Compression (8 Hours)
Color image processing: color model, enhancement, and segmentation; Compression: coding, quantization, spatial and transform domain based compression

Module VI Advanced Tools and Video Processing (8 Hours)
Statistical tools - Kalman Filter, Hidden Markov Models; Video Processing - Video standards, motion estimation, compression; Object representation and recognition

Suggested Books and References:

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson.
2. M. Sonka, V. Hlavac and R. Boyle, Image Processing, Analysis and Machine Vision, Cengage Learning
3. S. Sridhar, Digital Image Processing, Oxford University
4. B. Chanda and D. Dutta Mazumdar, Digital Image Processing and Analysis, Prentice Hall of India.

E. Advanced Database System Concepts

Module I (5hours):
Overview of DBMS, Structure of Relational Databases, Entity-relationship model, Relational Model, Integrity Constraints: Domain Constraints, Referential Integrity Constraints, Codd's Rules, Relational Calculus

Module II (6hours):
Functional Dependency, Different anomalies in designing a Database, Inference Rules, Armstrong's Axioms, Canonical Cover, Closure Property, Normalization:1NF, 2NF, 3NF, Boyce-Code Normal Form, Normalization using Multi-valued dependencies, 4NF, 5NF, Lossless Decomposition, Dependency Preservation Decomposition

Module III (6hours):
Transaction concept, ACID properties, Conflict & View Serializabilty, Test for Conflict Serializability, Concurrency Control, Lock Based Protocols, Two Phase Locking, Timestamps, Deadlocks

Module IV (4hours):
Physical & Logical Backup, Transaction Logs, Causes of Failures, Recovery Management.

Module V (5hours):
Storage Strategies, Single-Level Index (primary, secondary, clustering), Multi-level Indexes, Dynamic Multi-level Indexes, Hashing Techniques, B Tree and B+ Tree.

Module VI (6hours):
Stages in Query Processing, Query Plan, Query Processing Algorithms, Query Plan Execution, Join Algorithms, Equivalence Rules, Cost-Based Query Optimization, Statistics

Module VII (5hours):
Basic Concepts of Distributed Databases, Data Fragmentation, Replication and Allocation Techniques, Types of Distributed Database Systems, Query Processing, Overview of Client-Server Architecture and Its relationship to Distributed Databases.

Module VIII (6hours):
Overview of Object-Based Databases, Multidimensional Data Structures: k-d Trees, Point Quadtrees, the MX-Quadtree, R-Trees
Multimedia Databases: Design and Architecture of a Multimedia Database, Query Languages for Retrieving Multimedia Data, Indexing SMDSs with Enhanced Inverted Indices, Query Relaxation/Expansion
Graph Databases: Overview and Architecture, Introducing Cypher and Neo4J, Querying and Manipulating Data.

Module IX (5hours):
Advanced SQL, Integrity Constraints, Join Commands, Additional Join Operations, Set-Theoretic Operators, The HAVING Clause, Subqueries, Views, Cursors, Stored Procedures and Triggers, Introducing NoSQL

***Suggested Books and References*:**

1. Abraham Silberschatz, Henry F. Korth and S Sudarshan, "Database System Concepts", McGraw Hill Education.
2. Elmasri Ramez and Novathe Shamkant, "Fundamentals of Database Systems", Pearson Education.
3. Raghu Ramakrishnan and Johannes Gehrke,"Database Management Systems", McGraw Hill Education

4. Jim Gray and Andreas Reuter, “Transaction Processing: Concepts and Techniques”, Morgan Kauffman Publishers.
5. C.J. Date, “An Introduction to Database Systems”, Pearson Education
6. R. Panneerselvam, “Database Management Systems”, PHI Learning
7. Alexis Leon and Mathews Leon, “Fundamentals of Database Management Systems”, McGraw Hill Education
8. Ullman JD., “Principles of Database Systems”, Galgotia Publications.
9. V. S. Subrahmanian, “Principles of Multimedia Database Systems”, Morgan Kaufmann Punlication.
10. B. Prabhakaran, Multimedia Database Management Systems, Springer
11. I. Robinson, J. Webber, & E. Eifrem, Graph Databases, O’Reilly
12. Lynne Dunckley, Multimedia Databases: An Object Relational Approach, Pearson Education

F. Modeling and Simulation

Module I (10 hours) Introduction:
Simulation and Modeling Objectives, Examples of application in various fields, Modeling Concepts, Model Classifications General Concepts, Continuous and Discrete Models

Module II (22 hours) Statistical models:
Monte Carlo Simulation, Review of Basic Probability and Statistics, Stochastic Processes, Discrete Time Markov Chains, Petri Nets: Properties, Analysis and Applications, Variants of Petri Nets: Colored Petri Nets (CPN), Stochastic Petri Nets (SPN), Generalized Stochastic Petri Nets (GSPN)

Module III (8 hours) Random Number Generation and their variants:
Random Number Generators, Pseudo Random Number Generators, Testing Random Number Generators.

Module IV (8 hours) Simulation models:
Queuing Theory, Parallel/distributed simulation, Case studies.

Suggested Books and References:

1. A. Law and D. Kelton, “Simulation Modeling & Analysis”, McGraw Hill Publishing Co., 2002.
2. Kishor S. Trivedi, John Wiley and Sons, “Probability and Statistics with Reliability, Queuing, & Computer Science Applications”, New York, 2001.
3. Kuhl, Weatherly and Dahmann, “Creating Computer Simulation Systems: An Introduction to the High Level Architecture”, Prentice Hall, 2000.
4. P. Fishwick, “Simulation Model Design and Execution: Building Digital Worlds”, Prentice-Hall, 1995.
5. R.M. Fujimoto , “Parallel and Distributed Simulation Systems”, John Wiley, 2000.
6. M. Ajmone Marsan , “Modeling with Generalized Stochastic Petri Nets”, Wiley, 1995.
7. R. Jain, “The Art of Computer Systems Performance Analysis”, Wiley, 1991.
8. I. Mitrani, “Probabilistic Modeling”, Cambridge University Press, 1998.
9. Bernard P. Zeigler, Herbert Praehofer & Tag Gon Kim, “Theory of Modeling and Simulation”, Academic Press, 2000.

G. VLSI System Design

Module I (3 Hours)
REVIEW OF MICROELECTRONICS AND INTRODUCTION TO MOS TECHNOLOGIES: (MOS, CMOS, Bi-CMOS) Technology Trends and Projections.

Module II (6 Hours)
BASIC ELECTRICAL PROPERTIES OF MOS, CMOS & BiCMOS CIRCUITS: Ids -Vds Relationships, Threshold Voltage Vt, Gm, Gds and Wo, Pass Transistor, MOS,CMOS & Bi- CMOS Inverters, Zpu/Zpd, MOS Transistor Circuit Model, Latch-Up in CMOS Circuits.

Module III (4 Hours)
LAYOUT DESIGN AND TOOLS: Transistor Structures, Wires and Vias, Scalable Design Rules, Layout Design Tools.

Module IV (12 Hours)
LOGIC GATES & LAYOUTS: Static Complementary Gates, Pass Transistor Logic, Transmission Gate, Pseudo NMOS Logic, Complementary CMOS Logic, Domino Logic, NORA logic, DCVS Logic, Switch Logic, Alternative Gate Circuits, Low Power Gates, Resistive and Inductive Interconnect Delays.

Module V (8 Hours)
COMBINATIONAL LOGIC NETWORKS: Encoder, Decoder, Multiplexer, De-Multiplexers, Adders and Multipliers, Layouts, Simulation, Network delay, Interconnect Design, Power Optimization, Switch Logic Networks, Gate and Network Testing.

Module VI (4 Hours)
SEQUENTIAL SYSTEMS: Memory Cells and Arrays, Clocking Disciplines, Design, Power Optimization, Design Validation and Testing.

Module VII (7 Hours)
FLOOR PLANNING & ARCHITECTURE DESIGN: Floor Planning Methods, Off-Chip Connections, High Level Synthesis, Architecture for Low Power, SOCs and Embedded CPUs, Architecture Testing.

Module VIII (4 Hours)
EMERGING CONCEPTS: Synchronisers and arbiters, networks on a chip (NOC).

Suggested Books and References:

1. Essentials of VLSI Circuits and Systems, K. Eshraghian et . al(3 authors) PHI of India Ltd.,2005
2. Modern VLSI Design, 3rd Edition, Wayne Wolf , Pearson Education, fifth Indian Reprint, 2005.
3. CMOS DIGITAL INTEGRATED CIRCUITS ANALYSIS & DESIGN, Sung-Mo (Steve) Kang, Yusuf Leblebici, Tata Mcgrahill,
4. Principals of CMOS Design – N.H.E Weste, K.Eshraghian, Adison Wesley, 2nd Edition.
5. Introduction to VLSI Design – Fabricius, MGH International Edition, 1990.
6. CMOS Circuit Design, Layout and Simulation – Baker, Li Boyce, PHI, 2004.

H. CAD for VLSI

Module I (6 Hours)
PRELIMINARIES: VLSI Design Flow, Introduction to Design Methodologies, Design Automation tools, Algorithmic Graph Theory, Computational complexity, Tractable and Intractable problems, Field Programmable Gate Array (FPGA), Application specific Integrated circuits(ASICs) & design automation.

Module II (5 Hours)
Overview of Hardware modeling with VHDL/Verilog.

Module III (8 Hours)
HIGH-LEVEL SYNTHESIS: Hardware Models, Internal representation of the input Algorithm, Allocation, Assignment and Scheduling, Some Scheduling Algorithms, Some aspects of Assignment problem, High-level Transformations.

Module IV (6 Hours)
LOGIC SYNTHESIS AND VERIFICATION: Basic issues and Terminology, Binary-Decision diagrams, Two-Level logic Synthesis, Optimization of Combinatorial and Sequential circuits

Module V (14 Hours)
PHYSICAL DESIGN AUTOMATION: Physical Design Cycle; Partitioning; Floor Planning; Placement- Chip Array based and Full Custom Approaches; Routing– Maze routing, Multiple stage routing, Topologic routing, Integrated Pin – Distribution and routing; Compaction

Module VI (5 Hours)
TESTING: (Fault modeling, Simulation, Test generation) and Design for Testability**.**

Module VII (4 Hours)
Timing Analysis, Verification and Validation.

Suggested Books and References:

1. Algorithms for VLSI Design Automation, S.H.Gerez, 1999, WILEY Student Edition, John wiley & Sons (Asia) Pvt. Ltd.
2. Algorithms for VLSI Physical Design Automation – Naveed Sherwani, 3rd Ed., 2005, Springer International Edition.
3. Comoputer Aided Logical Design with Emphasis on VLSI – Hill & Peterson, 1993, Wiley.
4. Modern VLSI Design: Systems on silicon – Wayne Wolf, 2nd ed., 1998, Pearson Education Asia.

I. Fault Tolerant Systems

Module I (14 Hours)
Introduction, Fault Tolerant designs methodology. Hardware redundancy, TMR, GMR. Information redundancy, error control codes, parity codes, arithmetic codes. Residue codes, Hamming codes, sparse parity codes. Cyclic codes, Fire codes.

Module II (8 Hours)
Galois fields, BCH and Reed-Solomon codes, byte error detection. Convolution codes.

Module III (10 Hours)
Time redundancy, alternating logic, VLSI Fault Tolerant techniques. Fault Tolerant in computer units and computer systems. Radiation fault tolerant.

Module IV (16 Hours)
Fault Tolerant systems architectures. Fault Tolerant communication networks. Distributed Fault Tolerant systems. Byzantine general's algorithm. Fault-tolerant clock synchronization. Reliable remote procedure calls. Reliability evaluation techniques. Software for Fault Tolerant systems.

***Suggested Books and References*:**

1. Fault Tolerant and Fault Testable Hardware Design, Parag K. Lala, PHI, 1985
2. Fault Tolerant Computing Theory and Techniques-Volume I, D.K. Pradhan, PHI, 1986
3. Testing of Digital Systems, Niraj jha and Sandeep Gupta, Cambridge University Press, 2003
4. Fault Diagnosis and Fault-Tolerant Control Based on Adaptive Control Approach (Studies in Systems, Decision and Control) Qikun Shen , Bin Jiang , Peng Shi , Springer, 13 Mar 2019.
5. Fault Tolerance for Real-Time Embedded Applications: An operating system approach to support fault tolerance. Francisco Afonso. LAP Lambert Academic Publishing. ISBN: 9783838340685, 383834068X. 2010
6. Fault-tolerance techniques for high-performance computing. Thomas Herault. IIBN: 9783319209425, 3319209426. Springer, 2015.
7. Patterns for Fault Tolerant Software. Robert Hanmer, Wiley. 1st Edition
8. Fault Tolerance in Distributed Systems. Pankaj Jalote. ISBN-13: 978-0133013672 ISBN-10: 0133013677. Prentice Hall; 1 edition (April 16, 1994).

J. Cloud Computing

Module 1: [12L]
Introduction to Cloud Computing: Overview of distributed computing, Cloud introduction and overview, Different types of cloud services, cloud deployment models, Advantages and Disadvantages of Cloud Computing, and Companies in the Cloud today; Decision Factors for Cloud Implementations, Public, Private and Hybrid Cloud

Module 2: [12L]
Infrastructure as a Service (IaaS): Introduction to Infrastructure as a Service (IaaS), CPU Virtualization – Hypervisors, Storage Virtualization - SAN, ISCSI, Network Virtualization – VLAN;

Module 3: [12L]
Platform/ Software as a Service (PaaS/ SaaS): From IaaS to PaaS, What is PaaS, PaaS properties and characteristics, PaaS Techniques: File System - GFS, HDFS, Programming Model-MapReduce, Storage System for Structured Data - BigTable, Hbase.

Module 4: [12L]
SaaS: web service, web based applications, web portal; Security in Cloud computing environments: Cloud Computing threats, Security for Cloud Computing; Case studies: Amazon EC2, Google App Engine, IBM Clouds, Microsoft's Windows Azure etc.

Suggested Books and References:

1. Cloud Computing Techniques by IBM ICE Publication.

2. Cloud Computing Bible by Barrie Sosinsky, Wiley India Pvt. Ltd, 2013
3. Mastering Cloud Computing by Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, McGraw Hill Education (India) Private Limited, 2013
4. Cloud computing: A practical approach, Anthony T. Velte, Tata McGraw-Hill
5. Cloud Computing, Miller, Pearson.
6. IBM Data Centre Networking: Planning for Virtualization and Cloud Computing (IBM Redbook).

K. Wireless Sensor Network

Module 1 (12 hours):

Introduction and Overview of Wireless Sensor Networks: Introduction, Brief Historical Survey of Sensor Networks, and Background of Sensor Network Technology, Ah-Hoc Networks, Applications of Wireless Sensor Networks: Sensor and Robots, Reconfigurable Sensor Networks, Highway Monitoring, Military Applications, Civil and Environmental Engineering Applications, Wildfire Instrumentation, Habitat Monitoring, Nanoscopic Sensor Applications, Another Taxonomy of WSN Technology, Basic Sensor Network Architectural Elements, Home Control, Medical Applications, Basic Wireless Sensor Technology : Introduction, Sensor Node Technology, Sensor Taxonomy, WN Operating Environment, WN Trends, Wireless Network Standards: IEEE 802.15.4, ZigBee, IEE 1451

Module 2 (12 hours):

Medium Access Control Protocols for Wireless Sensor Networks: Introduction, Background, Fundamentals of MAC Protocols, MAC Protocols for WSNs: Schedule-Based Protocols, Random Access-Based Protocols, Coordination, Schedule Synchronization, Adaptive Listening, Access Control and Data Exchange (B-MAC,Box-MAC, Bit-MAC, H-MAC, I-MAC, O-MAC, S-MAC. Ri-MAC, T-MAC, Q-MAC (Querry MAC), Q-MAC (QoS MAC), X-MAC)

Module 3 (12 hours):

Routing Protocols for Wireless Sensor Networks: Introduction, Data Dissemination and Gathering, Routing Challenges and Design Issues in Wireless Sensor Networks Network Scale and Time-Varying Characteristics, Resource Constraints, Sensor Applications Data Models, Routing Strategies in Wireless Sensor Networks: WSN Routing Techniques, Flooding and Its Variants, Sensor Protocols for Information via Negotiation, Low-Energy Adaptive Clustering Hierarchy, Power-Efficient Gathering in Sensor Information Systems, Directed Diffusion, Geographical Routing

Module 4 (12 hours):

Transport Control Protocols and Middle wares for Wireless Sensor Networks: Traditional Transport Control Protocols: TCP (RFC 793), UDP (RFC 768), MobileIP, Introduction, WSN Middleware Principles, Middleware Architecture: Existing Middleware: MiLAN (Middleware Linking Applications and Networks), IrisNet (Internet-Scale Resource-Intensive Sensor Networks Services),

Operating Systems for Wireless Sensor Networks: Introduction, Examples of Operating Systems: TinyOS, Mate, MagnetOS

***Suggested Books and References*:**

1. Wireless Sensor Network by KazemSohraby, Daniel Minoli, TaiebZnati Pub: Wiley.
2. Wireless Sensor Networks Signal Processing and Communications by Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, John Wiley & Sons.

3. Ad Hoc Wireless Networks: Architectures And Protocols By Murthy Pub: Pearson Education
4. Wireless sensor networks Edited by C. S. Raghavendra Pub: Springer
5. Fundamentals of Sensor Network Programming: Applications and Technology By Sridhar S. Iyengar, Nandan Parameshwaran, Vir V. Phoha, N. Balakrishnan, Chuka D. Okoye, Wiley

L. Natural Language Processing

Module I Elementary Concepts (10hours)
Introduction to NLP, Regular Expression, Finite State Automata; Word Tokenization, Normalization, Sentence Segmentation, Named Entity Recognition, Multi Word Extraction, Spell Checking – Bayesian Approach, Minimum Edit Distance; Morphology – Inflectional and Derivational Morphology, Finite State Morphological Parsing, The Lexicon and Morphotactics, Morphological Parsing with Finite State Transducers, Orthographic Rules and Finite State Transducers, Porter Stemmer

Module II Language Modelling (8hours)
Introduction to N-grams, Chain Rule, Smoothing – Add-One Smoothing, Witten-Bell Discounting; Backoff, Deleted Interpolation, N-grams for Spelling and Word Prediction, Evaluation of language models; Markov Chain, Hidden Markov Models, Forward Algorithm, Viterbi Algorithm, Part of Speech Tagging – Rule based and Machine Learning based approaches, Evaluation

Module III Text Classification (8hours)
Text Classification, Naïve Bayes' Text Classification, Evaluation, Sentiment Analysis –Opinion Mining and Emotion Analysis, Resources and Techniques

Module IV CFG and Lexical Semantics (8hours)
Context Free Grammar and Constituency, Some common CFG phenomena for English, Top-Down and Bottom-up parsing, Probabilistic Context Free Grammar, Dependency Parsing; Introduction to Lexical Semantics – Homonymy, Polysemy, Synonymy, Thesaurus –WordNet, Computational Lexical Semantics – Thesaurus based and Distributional Word Similarity

Module V Text Processing (6hours)
Discourse Processing: Segmentation, Anaphora Resolution; Dialogue Systems; Natural Language Generation/Summarization; Unsupervised Methods in NLP

Module VI. Information Retrieval (8hours)
Boolean Retrieval, Term-document incidence, The Inverted Index, Query Optimization, Phrase Queries, Ranked Retrieval – Term Frequency – Inverse Document Frequency based ranking, Zone Indexing, Query term proximity, Cosine ranking, Combining different features for ranking, Search Engine Evaluation, Relevance Feedback

Suggested Books and References:

1. Jurafsky and Martin: Speech and Language Processing, Pearson Education.
2. Manning and Schutze: Foundation of Statistical Natural Language Processing, MIT.

Information Systems Lab-I

Code: CSE691
Contacts: 6P
Credits: 3

A. Advanced Data Structures and Algorithms
B. Advanced Image Processing
C. Advanced Database
D. Wireless Communication
E. Advanced Operating System
F. Advanced Software Engineering
G. Natural Language Processing

Semester II

Data Science

Code: CSE602
Contacts: 3L+1T
Credits: 4

Module I. Data Definitions and Analysis Techniques (6 Hours)
Elements, Variables, and Data categorization; Levels of Measurement; Data management and indexing; Introduction to statistical learning

Module II. Descriptive and Inferential Statistics (10 Hours)
Measures of central tendency; Measures of location of dispersions; Probability distributions; Inferential Statistics - Statistical hypothesis generation and testing; Chi-Square test; t-Test; Analysis of variance; Correlation analysis; Maximum likelihood test; Practice and analysis

Module III. Data Analysis Techniques (12 Hours)
Relation analysis; Regression analysis; Unsupervised learning -Clustering; Association rules analysis; Practice and analysis

Module IV. Supervised Learning (16 Hours)
Bias-Variance Dichotomy; Model Validation Approaches; Logistic Regression; Bayesin Classification, Linear Discriminant Analysis; Quadratic Discriminant Analysis; Regression and Classification Trees; Support Vector Machines; Ensemble Methods: Random Forest, Neural Networks, Deep learning

Module V. Case Studies and Projects (4 Hours)
Understanding business scenarios; Feature engineering and visualization; Scalable and parallel computing with Hadoop and Map-Reduce; Sensitivity Analysis

***Suggested Books and References*:**

1. Data Science from Scratch by Joel Grus, O'Reilly Publisher.
2. Probability and Statistics for Engineers and Scientists by R. Myers and R. Walpole, Pearson.
3. Big Data Analytics by SeemaAcharya and SubhasiniChellappan, Wiley Publisher.
4. Hadoop: The Definitive Guide by Tom White, O'Reilly Publisher.

Elective IV, V, VI

Code: CSE604, CSE606, CSE608
Contacts: 3L+1T
Credits: 4

A. Network Security and Cryptography

Module I. Introduction to Network Security (8 Hours)
Introduction to Security, Security Approaches, Principles of Security; Security Services and Mechanism-confidentiality, Confidentiality, Authentication, Integrity, on-repudiation, access Control and Availability; Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, location of encryption devices, key distribution Approaches of Message Authentication, Secure Hash Functions and HMAC. A model for Internetwork security, Internet Standards and RFCs, Buffer overflow & format string vulnerabilities, Introduction to TCP/IPTCP , fire walls, session hijacking, ARP attacks, route table modification, UDP hijacking, and man-in-the-middle attacks, Virtual Private Networks, Brief Study on Cryptography and Security

Module II. User Authentication Mechanisms and Public Key Infrastructure (10 Hours)
Introduction, Authentication Basics, Passwords authentication tokens, Certificate based authentications, Biometrics based authentication , Kerberos, X.509 Directory Authentication Service, SSO Approaches, Public key cryptography principles and algorithms, digital signatures, digital Certificates, Certificate Authority and key management, Public Key Cryptography Standards, Private Key Management, XML,PKI and Security, non-directory based authentication protocols, Attacks on authentication protocols, Authentication protocols in the real world.

Module III. Symmetric and Asymmetric Key Cryptographic Techniques (10 Hours)
Overview of symmetric Key Cryptography Algorithm types and modes; DES, IDEA, RC5, BLOWFISH, AES Algorithms; Differential and Linear Cryptanalysis, Overview of Asymmetric Key cryptography, RSA Algorithm, Symmetric and Asymmetric Key Cryptography Together, Digital Signature, Knap sack Algorithm and other Algorithms, provably secure and efficient public key cryptosystems.

Module IV. IP Security, Fire walls and Practical Implementation of Cryptography &Security (8 Hours)
IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management, Firewall Design principles, Trusted Systems, Intrusion Detection Systems. Cryptographic Solutions using Java, Cryptographic Solutions Using Microsoft, Cryptographic Tool Kit, Security and Operating Systems Pretty Good Privacy (PGP) and S/MIME.

Module V. Cryptosystems basics (6 Hours)
Probability and Information Theory and computational complexity and number theory, formal approaches to security establishment, semantic security and beyond, formal methods for protocol checking and analysis, Zero knowledge protocols.

Module VI. Digital Forensics (6 Hours)
Capturing evidence, working on the evidence, documenting and reporting with special emphasis on Internet/Email, network devices and mobile devices.

Suggested Books and References:

1. Network Security Essentials:Applications and Standards, William Stallings PEA.
2. Cryptography and Network Security, AtulKahate, Tata McGraw Hill
3. Modern Cryptography : Theory and Practices, W. Mao, Pearson Ed
4. Computer Forensics, David Cowen
5. The basics of digital forensics: the primer for getting started in digital forensics, J. Sammons.

B. Parallel Computing Techniques

Module 1 (12hours)
*Introduction:*Parallel Processing Environment- Pipelining and Data Parallelism, Scalability, Flynn's Taxonomy. Parallel Processing organization- Mesh, Hyper-tree, Pyramid, Butterfly, Hypercube network.
*Parallel Programming Platforms:*Implicit Parallelism: Trends in Microprocessor Architectures, Limitations of Memory System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines, Routing Mechanisms for Interconnection Networks, Impact of Process-Processor Mapping and Mapping Techniques.
*Principles of Parallel Algorithm Design:*Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction, Overheads, Parallel Algorithm Models.

Module 2 (12hours)
*Basic Communication Operations:*One-to-All Broadcast and All-to-One Reduction, All-to-All Broadcast and Reduction, All-Reduce and Prefix-Sum Operations, Scatter and Gather, All-to-All Personalized Communication, Circular Shift, Improving the Speed of Some Communication Operations.
*Analytical Modeling of Parallel Programs:*Sources of Overhead in Parallel Programs, Performance Metrics for Parallel Systems, Effect of Granularity and Data Mapping on Performance, Scalability of Parallel Systems, Minimum Execution Time and Minimum Cost-Optimal Execution Time, Asymptotic Analysis of Parallel Programs, Other Scalability Metrics.
*Programming Using the Message Passing Paradigm:*Principles of Message-Passing Programming, The Building Blocks: Send and Receive Operations, MPI: The Message Passing Interface, Topologies and Embedding, Overlapping Communication with Computation, Collective Communication and Computation Operations, Groups and Communicators.

Module 3 (12hours)
Programming Shared Address Space Platforms: Thread Basics, Why Threads? The POSIX Thread Application Programmer Interface, Synchronization Primitives in POSIX, Controlling Thread and Synchronization Attributes, Thread Cancellation, Composite Synchronization Constructs, Tips for Designing Asynchronous Programs, OpenMP: A Standard for Directive Based Parallel Programming.
Dense Matrix Algorithms: Matrix-Vector Multiplication, Matrix-Matrix Multiplication, Solving a System of Linear Equations.

Sorting: Issues in Sorting on Parallel Computers, Sorting Networks, Bubble Sort and its Variants, Quicksort, Bucket and Sample Sort, Other Sorting Algorithms.

Module 4 (12hours)
Graph Algorithms: Graph Definitions and Representation, Minimum Spanning Tree: Prim's Algorithm, Single-Source Shortest Paths: Dijkstra's Algorithm, All-Pairs Shortest Paths, Transitive Closure, Connected Components, Algorithms for Sparse Graphs.
Search Algorithms for Discrete Optimization Problems: Definitions and Examples, Sequential Search Algorithms, Search Overhead Factor, Parallel Depth-First Search, Parallel Best-First Search, Speedup Anomalies in Parallel Search Algorithms.
Dynamic Programming: Overview of Dynamic Programming, Serial Monadic DP Formulations, Nonserial Monadic DP Formulations, Serial Polyadic DP Formulations, Nonserial Polyadic DP Formulations.
Fast Fourier Transform: The Serial Algorithm, The Binary-Exchange Algorithm, The Transpose Algorithm, Cost-Effectiveness of Parallel FFT Algorithms.

Suggested Books and References:

1. Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, Introduction to Parallel Computing, Second Edition, Addison Wesley, 2003.
2. Michael J. Quinn, Parallel Computing: Theory and Practice, Second Edition, McGraw Hill Education, 2017.
3. S.G. Akl, Design and Analysis of Parallel Algorithms, Prentice-Hall.

C. Data Warehousing and Data Mining

Module 1 (10hours)
Introduction to Data Warehouse, A Multidimensional Data model: Stars, Snowflakes, and Fact Constellations, Concept Hierarchies, OLAP Operations in the Multidimensional Data Model, OLAP Systems versus Statistical Databases, Data Warehouse Architecture, Types of OLAP Servers: ROLAP versus MOLAP versus HOLAP, Data Warehouse Implementation, From Data Warehousing to Data Mining.

Module 2 (8hours)
Introduction to Data Mining: Overview, Motivation, Process of Knowledge Discovery, Data Mining Functionalities, Types of Data, Data Quality, Data Pre-processing, Measures of Similarity and Dissimilarity, Basic Statistical Descriptions of Data, Data Visualization.

Module 3 (10hours)
Classifications: What is Classification, Issues regarding Classification and prediction, Decision Tree Techniques, Rule-Based Classifiers, Nearest-Neighbor Classifiers, Bayesian Classifiers, Artificial Neural Network, Multilayer feed-forward Neural Network, Back propagation Algorithm, Support Vector Machine.

Module 4 (10hours)
Association Rule Mining: Definition, Basic concepts, Mining Association Rules in Large Databases, Frequent Itemset Mining Algorithms – Apriori Algorithm, Eclat Algorithm, FP-Growth Algorithm.

Module 5 (10hours)
Clustering: Clustering Analysis: What is Cluster Analysis? Partitioning Methods, Hierarchical Methods, Density-based Methods, Graph-Based Methods.

Suggested Books and References:

1. P. Tan, M. Steinbach and V. Kumar: Introduction to Data Mining, Addison Wesley, 2006.
2. J. Han and M. Kamber: Data Mining: Concepts and Techniques, 2nd Edition, Morgan Kaufmann, 2006.
3. Paulraj Ponniah: Data Warehousing Fundamentals for IT Professionals, Second Edition, Wiley India, 2010.

D. Theory of Computing

Module I (5hours)
Mathematical preliminaries, Models of Computation, Models of computation - classification, properties and equivalences. Finite Automata, Formal definition of a Finite Automata (FA) -Examples of FA, Designing FA, DFA and NFA, regular operations. Equivalence of NFAs and DFAs. FA with Epsilon-Transitions, Epsilon-Closures, Eliminating epsilon -Transitions. Applications of FAs. Mealy and Moore machine, Dead state, Minimization of FA, Incompletely specified machine. FA on infinite inputs.

Module II (5hours)
Regular expression and Languages, Definition of a Regular Expressions (RE), The Operators of RE – Building RE, Conversions DFA's to RE. Equivalence of RE and NFA with Epsilon-moves, Application of REs. Equivalence of regular grammar and FA, Properties of Regular Languages (RL), Proving Languages not to be Regular, Pumping Lemma for RLs. Applications of the Pumping Lemma. Closure Properties of RLs, Decision Properties of RLs.

Module III (6hours)
Context Free Languages, Context free languages, Derivation and languages, Relationship between derivation and derivation trees, Leftmost and Rightmost Derivations. Simplification of context free grammars – Normal forms for context free grammars, CNF, and GNF. Applications of Context-Free Grammars. Non-determinism vs. ambiguity in CFLs. Closure properties of CFLs. Algorithmic properties about CFLs. Pumping Lemma for CFL.

Module IV (4hours)
Push Down Automata, Definition, Acceptance by a Push Down Automata (PDA), DPDA & NPDA, example, Equivalence of PDA's and CFG's (conversion : PDA's to CFG's and reverse). Multi stack PDA. Non-determinism adds power to PDAs.

Module V (6hours)
Turing Machine, Unsolvable Problems. Definition, notation and Example of Turing Machine (TM).
Programming techniques Computable languages and functions, Church Turing hypothesis, Universal TM,
Random Access TM. Multitape TM, Equivalence of One-Tape and Multitape TM's, Nondeterministic TMs. Conversion of RE to TM. Multi-stack PDA & TM.

Module VI (8hours)

Computability and Decidability: Church-Turing Thesis, Decision Problems, Decidability and undecidability, unsolvable problems; Halting Problem of Turing Machines; Problem reduction (Turing and mapping reduction),Intractability (Hierarchy Theorems). Mapping reductions. More undecidable languages. Rice theorem. Reductions using controlled executions. RE Completeness. Reductions using computation histories. Linear Bounded Automata. Unrestricted grammars.

Module VII (8hours)

Computational Complexity, Resource-constrained computation. Time Complexity- notion of complexity classes, classes P NP, NP-complete, Boolean satisfiability, NP-Completeness of CSAT and 3SAT, NP- Levin Theorem. The concept of reduction, coNP, polynomial Hierarchy. Some natural NP-complete problems. Space Complexity-Savich's Theorem. The class PSPACE. Optimization, search, and decision problems. Approximate solutions to optimization problems.

Module VIII (6hours)

Logic, Propositional and First-order logic and their applications to theorem proving and logic programming. Advanced/Emerging areas: Elementary introductions to DNA Computing, Quantum Computing, Cellular Automata, Circuit complexity, Structural Complexity, Parallel Complexity, Algorithmic Information.

Suggested Books and References:

1. John E. Hopcroft, Rajeev Motwani and Jeffery D. Ullman: "Introduction to Automata Theory, Languages, and Computation", Pearson Education
2. Michael Sipser, "Introduction to the Theory of Computation", Cengage Learning
3. H. R. Lewis and C. H. Papadimitriou: "Elements of the Theory of Computation", Pearson Education
4. John C Martin, "Introduction to Languages and the Theory of Computation", McGraw Hill Education
5. Peter Linz: "An Introduction to Formal Languages and Automata", Jones & Bartlett Publisher
6. ZVI Kohavi and Niraj K Jha: "Switching and Finite Automata Theory", Cambridge University Press
7. Dexter C. Kozen: "Automata, Computability and Complexity: Theory and Applications", Springer-Verlag New York Inc.
8. Daniel I.A. Cohen: "Introduction to Computer Theory", John Wiley
9. C.K.Nagpal: "Formal Languages and Automata Theory", Oxford University Press
10. K L P Mishra and N Chandrasekaran: "Theory of Computer Science: Automata, Languages and Computation", PHI

E. Multimedia Technologies

Module I (10 hours) Introduction:
Multimedia Elements, Multimedia Applications, Multimedia System Architecture, Evolving Technologies for Multimedia Systems, Multimedia Databases

Module II(9 hours) Input and output:
Key Technology Issues, Pen Input, Video and Image Display Systems, Print Output Technologies, Image Scanners, Digital Voice and Audio, Video Images and Animation, Full Motion Video.

Module III(10 hours) Storage and retrieval:
Magnetic Media Technology, RAID-Level-0 To 5, Optical Media, WORM optical drives, Hierarchical Storage Management, Cache Management for storage systems.

Module IV(9 hours)Compression and Decompression Techniques:
Types of Compression, Binary Image Compression Schemes, Color, gray scale, still-video image compression, Discrete Cosine Transform, Video Image compression, Data and File format standards- JPEG, TIFF,RIFF, MIDI, AVI Architecture.

Module V(10 hours) Application design:
Types of Multimedia systems - Virtual Reality Design - Components of Multimedia system - Distributed Application Design Issues - Multimedia Authoring and User Interface - Hypermedia Messaging - Distributed Multimedia Systems

Suggested Books and References:

1. J. Keyes: Multimedia Handbook, MH.
2. G. Blair, L. Blair, A. Chetwynd, H. Bowman: Formal Specification of Distributed Multimedia Systems, UCL Press, London.
3. S. Khoshafian, A. Brad Baker: Multimedia and Imaging Databases, Morgan Kaufmann.
4. Andleigh PK and Thakrar K, "Multimedia Systems", Addison Wesley Longman, 1999.
5. Fred Halsall, "Multimedia Communications", Addison Wesley, 2000.
6. Ralf Steinmetz, Klara Nahrstedt, "Multimedia, computing, communications and applications", Prentice Hall, 1995.
7. Tay Vaughan, "Multimedia: Making It Work", TMH 5th Edition 2001.
8. Weixel, Fulton, Barksdale. Morse, "Multimedia Basics", Easwar Press 2004.

F. Bioinformatics

Module I. Introduction to Bioinformatics (4hours)
Why computational biology? Fundamentals of molecular biology, Central dogma, Important tasks in computational biology.

Module II. Pairwise Sequence Alignment (8hours)
Introduction to biological sequences, Sequence comparison overview, Homology vs. Similarity, Need for sequence alignments, Alignment Algorithms: global and local, Substitution matrices: PAM and BLOSUM, Gap penalty functions, Scoring alignments, Dynamic programming approach in sequence alignments, Needleman-Wunsch algorithm, Smith-Waterman algorithm.

Module III. Multiple Sequence Alignment (6hours)
Dynamic Programming in 3-D, Progressive Alignment, Profile Progressive Alignment (ClustalW), Scoring Multiple Alignments: multiple LCS score, Entropy and Sum of Pairs (SP) score, Partial Order Alignment (POA), A-Bruijin (ABA) Approach to Multiple Alignment.

Module IV. Fragment Assembly (4hours)
Overview of the genome sequencing process, What is Fragment Assembly? Shotgun Sequencing Solution: Break, Sequence and Assemble, A simple model, Sequencing Errors, Problems with the simple model.

Module V. Phylogenetic Analysis (8hours)
Goals of Molecular Phylogeny, Common Phylogenetic Tree Terminologies, Inferences from phylogenetic trees, rooted and unrooted trees, Molecular phylogenetic tree building methods, Distance Matrix Algorithms: UPGMA and Neighbor-Joining, Parsimony Based Approach: Big and Small Parsimony, Fitch's Algorithm, Computational methods for finding optimal trees: Exact vs. Heuristic algorithms, Branch and Bound Heuristic: The MP search tree.

Module VI. Microarray Gene Expression Analysis (10hours)
DNA Microarray Technology, Representation of Microarray Data and Transformations, Distance measures, Clustering methods: hierarchical vs. non-hierarchical clustering, classification techniques, evaluation of classifiers, Relating expression data to other biological information.

Module VII. Biological Network Analysis (8hours)
Types of biological networks, Properties of biological networks, Global Network Properties, Inferences from biological networks, Computational problems in network biology.

Suggested Books and References:

1. Jin Xiong: "Essential Bioinformatics", Cambridge University Press
2. Marketa Zvelebil and Jeremy Baum: "Understanding Bioinformatics", Garland Science
3. Joachim Selbig and Stefanie Hartmann: "Introductory Bioinformatics",Books on Demand
4. Jonathan Pevsner: "Bioinformatics and Functional Genomics", Wiley-Blackwell
5. Pavel Pevzner and Ron Shamir: "Bioinformatics for Biologists", Cambridge University Press
6. Joao Meidanis and Carlos Setubal, "Introduction to Computational Molecular Biology", Cengage Learning
7. Neil J. Jones and Pavel A. Pevzner,"Introduction to Bioinformatics Algorithms", ANE Books
8. Bernhard Haubold and Thomas Wiehe, "Introduction to Computational Biology: An Evolutionary Approach", Birkhäuser Publisher
9. S.C. Rastogi, N Mendiratta and P Rastogi: "Bioinformatics: Methods & Applications", PHI
10. Stanley I. Letovsky: "Bioinformatics: Databases and Systems", Springer-Verlag New York Inc.

G. Advanced Machine Learning

Module1 (18 hours)
Introduction: Overview of topics and applications
Supervised Learning: Linear Regression: gradient descent, Normal equations. Probabilistic Interpretation, Logistic Regression, Newton's method, Locally weighted Linear Regression, Nearest Neighbors, Exponential Families, Generalized Linear Models, Optimization: Convex functions,

Convex problems, Generative Learning Algorithms, Gaussian Discriminant Analysis, Feature selection, Kernels, Support vector Machine.

Module 2 (18 hours)
Unsupervised Learning: Curse of Dimensionality, Dimensionality Reduction, PCA, Mixture of Gaussians, EM Algorithm. Examples of EM, clustering, spectral clustering. Multi-dimensional Scaling (MDS), Isomaps, Non Negative Matrix Factorization.

Module 3 (12 hours)
Probabilistic Graphical Models: Introduction, Representation, Markov Blanket, variable elimination, HMM, Inference on a chain (sum-product specific case), Kalman Filters, Directed / Undirected graphs, MRFs, Sum-product, Max-product,
Special Topic: Graphical Models, Deep Learning.

Suggested Books and References:

1. The Elements of Statistical Learning Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer, 2009.
2. Gaussian Processes for Machine Learning Carl Edward Rasmussen and Christopher K.I. Williams, MIT Press, 2006.
3. Non-Uniform Random Variate Generation Luc Devroye, Springer-Verlag, 1986.
4. Probabilistic Graphical Models: Principles and Techniques Daphne Koller and Nir Friedman, MIT Press, 2009

H. Internet of Things

Module 1 (8 Hours):
Introduction to IoT: Introduction of Internet of Things (IoT): History of IoT, Overview and Motivations, Examples of Applications.
Internet of Things Definitions and Frameworks: IoT Definitions, IoT Architecture, General Observations, ITU-T Views, Working Definition, IoT Frameworks.
Basics of Networking: Sensing, Actuation.
Communication Protocols: Sensor Networks.

Module 2 (10 Hours)
IoT Technologies and Machine-to-Machine Communications: A Basic Perspective– Introduction, industrial structure for IoT, The international driven global value chain and global information monopolies. IoT Architecture, Key IoT Technologies, Device Intelligence, Communication Capabilities, Mobility Support, Device Power, Sensor Technology, RFID Technology, Satellite Technology.
M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

Module 3 (10 Hours)
Resource Management in IoT: Clustering, software agents in IoT, Identity Management in IoT, various identity management models: Local Network, Federated and global web identity, user-centric identity management, device centric identity management and hybrid-identity management, Identity and trust.
Case Study: Smart Cities, Smart Grid, Industrial IoT, Smart Agriculture etc.

Module 4 (10 Hours)

Security and Business Model in IoT: IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, Non-repudiation and availability, Security model for IoT.

Business Models and Business Model Innovation, Value Creation in the Internet of Things, Business Model Scenarios for the Internet of Things. Internet of Things Application: Smart Metering, e-Health, Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards.

Module 5 (10 Hours)

Developing IoTs: Introduction to Python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementation of IoT concepts with python, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi.

Suggested Books and References:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014.
2. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM – MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
4. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications
5. Vijay Madisetti and ArshdeepBahga, “Internet of Things (A Hands-onApproach)”, 1st Edition, VPT, 2014.
6. http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html
7. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
8. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)

I. Big Data Analytics

Module I (7 hours) Introduction:

Big Data and its Importance – Four V’s of Big Data – Drivers for Big Data – Introduction to Big Data Analytics – Big Data Analytics applications.

Module II (5 hours) Basic Statistics with R/ Python:

Basic statistical concepts with a brief review of R (a language very much used by statisticians), Python

Module III (8 hours) Machine Learning Recapitulation:

Introduction and Concepts Differentiating algorithmic and model based frameworks, Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K-NN, Regression & Classification, Supervised Learning with Regression and Classification techniques, Bias-Variance Dichotomy, Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Regression and Classification Trees, SVM, Ensemble Methods: Random Forest, Neural

Networks, Deep learning, Unsupervised Learning and Challenges for Big Data Analytics Clustering, Associative Rule Mining, Challenges for big data analytics.

Module IV (5 hours) Data Analytics with R/Python Machine Learning:
Introduction, Classification, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with Big R.

Module V (20 hours) Big data with Hadoop:
Hadoop's Parallel World, Data discovery, Open source technology for Big Data Analytics, Cloud and Big Data Predictive Analytics, Big Data with Crowd Sourcing Analytics, Inter- and Trans-Firewall Analytics - Information Management, Integrating disparate data stores - Mapping data to the programming framework - Connecting and extracting data from storage - Transforming data for processing - Subdividing data in preparation for Hadoop, Map Reduce. Employing Hadoop Map Reduce - Creating the components of Hadoop Map Reduce jobs - Distributing data processing across server farms -Executing Hadoop Map Reduce jobs - Monitoring the progress of job flows - The Building Blocks of Hadoop Map Reduce - Distinguishing Hadoop daemons - Investigating the Hadoop Distributed File System Selecting appropriate execution modes: local, pseudo-distributed, fully distributed.

Module V (4 hours) Big data with Hive:
Introduction to HIVE & e-HIVEQL - Using Hive to query Hadoop files.

Suggested Books and References:

1. Hastie, Trevor, et al., The elements of statistical learning. Vol. 2. No. 1. New York: Springer, 2009.
2. Montgomery, Douglas C., and George C. Runge., Applied statistics and probability for engineers. John Wiley & Sons, 2010.
3. Michael Minelli, Michehe Chambers, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Business", Wiely CIO Series, 2013.
4. Arvind Sathi, "Big Data Analytics: Disruptive Technologies for Changing the Game", 1st Edition, IBM Corporation, 2012.
5. Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", 1st Edition, Wiley and SAS Business Series, 2012.
6. Tom White, "Hadoop: The Definitive Guide", 3rd Edition, O'reilly, 2012.

Information Systems Lab-II

Code: CSE692
Contacts: 6P
Credits: 3

A. Data Science
B. Big Data Processing
C. Network Security and Cryptography
D. High Performance Computing
E. Data Mining

F. Multimedia
G. Bioinformatics
H. Advanced Machine Learning
I. Internet of Things

Interim Term Paper

Code: CSE672
Contacts: 3P
Credits: 2

Students will prepare term papers related to their project areas in consultation with their supervisor(s).

Seminar

Code: CSE682
Contacts: 3P
Credits: 2

Seminar presentation has to be delivered preferably on project related area.

Semester III

Elective VII

Code: CSE701
Contacts: 3L+1T
Credits: 4

Selected topics preferably related to current trends/research are to be covered. Groups may be formed if required.

Dissertation-I

Code: CSE771
Contacts: 24P
Credits: 12

Semester IV

Dissertation-II

Code: CSE772
Contacts: 32P
Credits: 16

Comprehensive Viva-Voce

Code: CSE784
Contacts: 0
Credits: 2