Syllabus

for

4-Years B. Tech. in Computer Science & Engineering

Effective from 2019-2020 Academic Session

Department of Computer Science and Engineering
National Institute of Technology Sikkim
South Sikkim - 737 139

First Semester

CS11101	Computer Programming and Problem Solving	2-0-0	2

Module 1[3L]: Problem Solving Skills, Identify the Problem, Analyze the problem, Identify Decision Criteria, Develop Multiple Solutions, Choose the Optimal Solution, Problem Implementing Solutions.

Module 2 [3L]: Overview of C language, Basic Structure of C program, Constants, Variables and Data Types, User-defined Data Types, Operators and Expressions, Precedence and Associativity.

Module 3[10L]: Input-Output Operations, Decision Making, Branching and Looping Statements, Arrays, Character Arrays and Strings.

Module 4[12L]: User-defined Functions, Structures, Unions, Debugging Strategies.

Module 5[12L]: Pointers, Dynamic Memory Allocations, File Management, Introduction to Preprocessor Commands and Macro Processing, argv, argc.

Books:

1. C Programming by Deital and Deital.
2. Programming in ANSI C, E. Balaguruswamy, 5th Edition McGraw Hill.
3. The C Programming Language, Brian W. Kernighan, Dennis M. Ritchie, Prentice Hall.
4. Programming With C, Byron Gottfried, McGraw Hill.

CS 11201	Computer Programming and Problem Solving Laboratory	0-0-4	2

- Input and Output programs
- Control Loop programs
- Conditional Execution programs
- Structure and Nesting programs
- Functions and Prototype programs
- Array programs
- Pointer programs

Books:

1. C Programming by Deital and Deital.
2. Schaum's Outline of Programming with C by Byron Gottfried
3. Programming in ANSI C by E. Balagurusamy

CS11102	Introduction to Computer Systems	2-0-0	2

Module 1 [6L]: Number System and Codes: Data Representation, Concept of Radix and Representation of Numbers in Radix r with Special Case of r=2, 8, 10 and 16; Conversion from Radix r1 to Radix r2; General Concept of r's and (r-1)'s Complements; Signed and Unsigned Representation of Integer, 1's, 2's Complement and Floating Point and their Machine Representation. Binary Arithmetic; Character Representation-ASCII, EBDIC, UNICODE.

Module 2 [6L]: Programming Languages and Translators – Concept of High-Level, Assembly and Low Level Languages, Relative Merits & Demerits, Working of Assembler, Interpreter and Compiler. Problem Solving through Algorithm, Flow-chart, Pseudo Code.

Module 3 [6L]: Introduction: Stored Program Architecture of Computers and Block Diagram, Evolution of Processors (In terms of word Length & Speed, Instructions per Second), Hardware and Software, Classification of Computer System, Computer Architecture- RISC vs CISC, Concept of Primary & Secondary Memory, Storage Devices Classification, Hierarchy, Working Principle, Access Methods, Structure of Hard Disk System & Organization of Data; Cache Memory.

Module 4 [6L]: Introduction to Multiprogramming: Multitasking, Multiprocessor, Time-sharing, Batch-processing, Interactive Computing; Distributed, Client-Server, Peer-to-Peer Systems. **Introduction to Operating System:** Need for Operating System, Functions of Operating System (Functions of Process Management, Memory Management, File Management and Device Management), An Introduction to Linux OS and Commands. Classification of Software's: System Software, Application Software. Open Source Software.

Books:

1. Computer Fundamentals by P. K. Sinha & Priti Sinha, BPB Publications, 1992.
2. Introduction to Computers by Norton Peter, 4th Ed., TMH, 2001
3. Fundamentals of Computers by Reema Thareja, Oxford University Press, 2014.
4. Introduction to Computers by V. Raja Raman, PHI,
5. Introduction to Computers by Alex Leon & Mathews Leon, Vikas Publishing House, 1999.
6. Comdex Computer Kit by Vikas Gupta, Wiley Dreamtech, Delhi, 2004

Second Semester

CS12101	Foundation of Computing	3-0-0	3

Module 1 [12L]:Linear Data Structure
Introduction of Data Structure; Need and Applications; Abstract Data Type; Dynamic Memory Allocation; Array; Linked List; Stack and Queues; Priority Queues - Implementation and Applications.

Module 2 [6L]: Sorting, Searching; Sorting techniques- need; Types of Sorting, selection sort, Quick Sort; Searching techniques: need; Linear Search, Binary Search; Implementation and Applications of all.

Module 3[6L]: Introduction to Logic: Propositional Logic, Predicate Logic.

Module 4[8L]:Computer Networks and Internet Basics
Computer Networks and Internet, Categories of Networks: Wired, Wireless, Sensor, LAN, WAN, PAN; network topologies need, and type, network switching: Packet and Circuit Switching, Protocol Layers and their functions (example protocol on each layer), Application Layer Protocols, E-mail, FTP, WWW and HTTP. Introduction to Cyber Security and Forensics with needs.

Module 5[8L]: Introduction to Machine Learning, Artificial Intelligence and Fuzzy logic, Internet of Things, Natural Language Processing, Big Data, Mobile Computing, Cloud Computing.

Books:

1. Data structures in C by H. Sahani
2. Computer Networking: A Top-Down Approach Featuring Internet by J. F. Kurose and K. W. Ross, 3/e, Pearson Education, 2005.
3. Machine Learning by Tom Mitchel, TMH

Reference:

4. Data Structures by Tanenbum
5. Data Communications and Networking by Forouzan

CS12201	Computing Laboratory	0-0-2	1

1) You are required to write the programs in c on the integer array for following operations
   a. To insert the elements in the integer array and to display the number of negative elements of the array and also to display the prime elements of the array.
   b. Write function that can find the largest element in the array. Array must be used as parameter.
   c. Write a program that invokes the above function (b) to find the largest element and print it out.
   d. Write function that can find the largest element in the integer array using pointer arithmetic.
   e. Write a program that invokes the above (d) function to find the largest element and displays the result out.

2) You are required to write the program in C to:
   a. Define a structure with two fields: width and height for rectangle. Input an array of rectangle, then display each area and perimeter of each rectangle in array.
   b. Use the pointer to loop around the array for the same (a).

3) Write a program in c that receives a number n and return a pointer to the character string containing the name of the corresponding month.

4) You are required to define a structure named UP with the following three members:
   - A character array city[] to store names.
   - A long integer to store the population of the city.
   - A float member to store the literacy level.

   Then write a program to do the following:
   a. To read the details of 5 cities randomly using an array variable.
   b. To sort the list alphabetically.
   c. To sort the list based on literacy level.
   d. To sort the list based on population.
   e. To display the sorted lists.

5) As you have studied structure and pointer in the last semester. You are required to write programs using structure containing a pointer member name to represent the information about a person.
   a. Toread the information about a person and to print it on the screen.
   b. To initialize data of several employees and print it in tabular format. Use the function emp_print() the data of a single employee.
   c. To create and print a list of persons and their mobile number. Use nested structure and pointer members.

6. Write a program to implement a single link list to perform the following operations
   a. Insertion at the beginning, at end and at any position of the list.
   b. Deletion at the beginning, at end and at any position of the list.
   c. Traverse the single link list
7. Write a program to implement stack using static and dynamic representation and perform Insertion and Deletion.
8. Write a program to implement queue using static and dynamic representation and perform Insertion and Deletion.
9. Write a program to implement binary tree using link list.
10. Write a program to implement linear and binary search.
11. Write a program to sort a list of elements using bubble sort and selection sort.

Third Semester

CS13101	Data Structure & Algorithms	3-0-0	3

Module 1 [8L]: Introduction
Concept and classifications of Data Structures, Concepts of Abstract definition of Data Types, Concept of Time and Space complexity, Asymptotic Notations.

Module 2[12L]: Stack, Queue, Linked List
Abstract definition (ADT), applications in various domains of computer science.
Stack: Representation, elementary operations and applications such as infix to postfix, postfix evaluation, parenthesis matching, Multi-stack, recursion using stack.
Queue: Simple queue, operations, circular queue, dequeue, priority queue.
Linked list: Linear, circular and doubly linked list, operations.

Module 3 [10L]: Tree and Graph
ADT, terminology, operations and applications in various domains of computer science.
Tree: Classifications of trees, Binary Tree, Representation, Binary Tree Traversal, Threaded Binary Tree: operations, Heap tree (Max, Min), Binary Search tree: operation.
Graph: Representations, Graph Traversal: BFS, DFS, Topological Sort.

Module 4[10L]: Sorting and Searching
Sorting: Selection Sort, Bubble Sort, Quick Sort, Merge Sort, Heap Sort, Radix Sort, Searching: Linear and Binary Search.
Hashing – Direct-address tables, open addressing, hash functions.

Books:

1. Data Structures Using C by Aaron M. Tenenbaum, Y. Langsam, Moshe J. Augenstein.
2. Data structures and Algorithms with Object oriented design paterns in C++ by Bruno R. Preiss.
3. Data Structures and Program Design in C by Robert L. Kruse
4. Fundamental of data Structure in C by E. Horowitz, S. Sahni and S. Anderson-Freed.
5. Data Structures and Algorithms by A. V Aho, J. D Ullman and J. E Hopcroft, Addison Wesley.

CS13102	Data Communications	3-0-0	3

Module 1[9L]: Introduction- Computer Networks and Internet philosophy; Data Communication, Data Transmission Modes, Signaling and Transmission, Types Communication Channels, Periodic Analog Signals, Digital signals, Transmission Impairments, Bandwidth and Data Rate Limits, Communication Line performances. Digital Transmission, Bandwidth Utilization: Multiplexing, Spread Spectrum.

Module 2[9L]: Concept of Layering, TCP/IP and OSI Layering Models, Transmission Media: Guided Media, Unguided Media, Fibre-optic cables, Telephone Line and Modems. Switching: Circuit Switched Networks, Packet Switching, and Structure of a Switch. Delay and loss, Communication Process, the network edges: Distributed Systems and Networks, Peer to Peer and Client Server Networks, Network Topologies, Network Components, Connections.

Module 3[9L]: Data Link Layer: Link Layer Services, Link Layer Addressing: MAC Addresses, ARP, RARP, DHCP. Error Detection and Correction Techniques: Introduction, Block Coding, Cyclic Codes, Checksum, Forward Error Correction. Framing Techniques, Flow and Error Control protocols: Simplest and Stop & Wait protocol, Sliding Window Protocol.

Module 4 [9L]: MAC: Access Control Protocols: Random Access Protocols, Controlled Access Protocols, Fast access technologies, Ethernet, Hubs, Bridges, Gateway, Repeaters, Switches, PPP, MPLS, and VLAN. Token Rings (IEEE 802.5).

Books:

1. Computer Networking: A Top-Down Approach Featuring Internet by J. F. Kurose and K. W. Ross, 3/e, Pearson Education, 2005.
2. Data Communications and Networking by Behrouz A. Forouzan, Fifth Edition, 2013
3. Data and Computer Communications by William Stallings, Eighth Edition, 2012
4. Computer Networks, A systems Approach by Peterson L.L. & Davie B.S, 3/e, Harcourt Asia, 2003.
5. Computer Networks by Andrew S. Tanenbaum, 3/E, PHI, 1996.

CS13103	Digital Logic Design	3-0-0	3

Module 1 [10L]: Review of number systems and Boolean algebra: postulates and theorems, constants, variables and functions, switching algebra, Boolean Functions and Logical Operations. Karnaugh Map: prime cubes, Minimum Sum of Products and Product of Sums. Quine-McCluskey algorithm, prime implicant chart, cyclic prime implicant chart, Petrick's method.

Module 2 [10L]: Combinational Logic: Introduction, Analysis And Design Of Combinational Logic Circuits, Arithmetic Circuits, Parallel Adders and Look-ahead Adders, Comparators, Parity Generators and Checkers. Decoders and Encoders, Code Conversion, Multiplexers and Demultiplexers, ROM, PAL, PLA.

Module 3 [10L]: Introduction to Sequential Circuits: Latches and Flip-Flops (RS, JK, D, T and Master Slave). Design of a Clocked Flip-Flop – Flip-flop conversion - Practical Clocking Aspects Concerning Flip-Flops. Multivibrator and its type. Counters: Design of single mode counters and multimode counters – Ripple Counters – Synchronous Counters. Shift registers – Shift Register counters – Random Sequence Generators.

Module 4 [6L]: Digital Logic Families – Fundamentals Of RTL, DTL, ECL, And TTL. Characteristics of Logic Families and its Comparison: Speed And Propagation Delay, Transition Time, Fan in, Fan out, Power Dissipation, and Noise Immunity. Basic CMOS Inverter Circuit, Inverter Using NMOS. Interfacing Between Different Logic Families.

Books:

1. Digital Fundamentals by T. L. Floyd, R. P. Jain, 8/e, Pearson Education, 2006.
2. Fundamentals of Logic Design by C. H. Roth, Jr., L. L. Kinney, 6/e, Cengage Learning, 2009.
3. Digital Design by M. M. Mano, M. D.Ciletti, 4/e, Pearson Education, 2008.
4. Digital Integrated Electronics by Taub and Schilling, MGH,1998.
5. Digital Systems - Principles and Applications by R. J. Tocci and N. S. Widner, Prentice Hall, 10^{th} Ed., 2007.
6. Digital Design: Principles and Practices by J. F. Wakerly, Prentice-Hall, 2nd Ed., 2002
7. Contemporary Logic Design by R. Katz, Addison Wesley, 1993.

CS13104	Object Oriented System Design	3-0-0	3

Module 1[8L]: Concepts of Object-Oriented Programming: Procedure Oriented Programming, Object Oriented Programming. Properties of Object-oriented models. Concepts of Classes and Objects, Nature of an object, Nature of a class, Relationships among objects and classes. Modeling techniques of classes and objects. Paradigms of Object oriented programming. Overview of abstraction. Information hiding. Polymorphism. Method Overloading. Inheritance. Method overriding. Dynamic Binding. Message Passing. Exceptions and Exception handling. Container classes. Object Oriented Design – Process, Exploration and Analysis. Benefits of Object-Oriented Programming.

Module 2[9L]: Fundamentals of Java: Basics of Java: JVM and Bytecode, Advantages of Java. Data types, variables, expressions. Control Statements. Type conversion and casting. Automatic type promotion. **Implementation of Object-Oriented Programming using Java:** Java Classes and Objects, Declaring objects, Constructors. this pointer. Garbage Collection. finalize() method. Method and constructor overloading. Nested and Inner class. **Inheritance:** Implementation of inheritance. super pointer. Multilevel class hierarchy. Method overriding. Abstract classes. Interfaces. Packages.

Module 3[10L]: Intermediate Java: Exception Handling: Fundamentals. try and catch keywords. Nested try. throw, throws, finally keywords. Java's built-in exceptions and creating custom exceptions. **Multithreaded Programming**: Basic concept of threading, Java thread model. The main thread. Creating custom thread. isAlive() and join() methods. Thread priorities. Synchronization. Suspending, Resuming and Stopping threads. The Concurrent API.

Module 4[9L]: Advanced Java: **Java IO and Applets**: Reading and Writing to Console. PrintWriter class. Reading and Writing to files. Formatting output. Automatically closing a file. Applet Fundamentals. **Generics and Lambda Expressions**: Generic class, Bounded types. Wildcard arguments. Creating generic methods. Generic Class Hierarchies. Lambda Expressions. Method references.

Books:

1. Object-Oriented Analysis and Design with Applications by Grady Booch et. al.
2. Object-Oriented Modeling and Design With UML by Blaha, Rumbaugh
3. Java: The Complete Reference 9th Edition by Herbert Schildt
4. Effective Java by Joshua Bloch

CS13105	Computational Mathematics	3-1-0	4

Module 1 [7L]: Number Theory
Integers, Divisibility, Prime Numbers, Primality Testing, Unique Factorization, Chinese Remainder Theorem, Congruence, Quadratic Congruence, Exponential and Logarithm, Discrete Logarithms, Quadratic Reciprocity, Diophantine Equations and Arithmetic Functions, Modular Arithmetic, GF(2^n) Fields, P≠NP Conjecture, 1-way Functions.

Module 2 [7L]: Optimization Techniques
Introduction to Linear Programming Model, Graphical Method, Assignment Problem, Transportation Methods, Simplex Method, Nonlinear Optimization.

Module 3 [5L]: Set, Relation, Functions and Operations

Module 4 [9L]: Graph Theory and Combinatorics
Introductions, basic Terminology, Simple Graph, Multi-graph, Pseudo-graph, Degree of a Vertex, Types of Graphs, Sub-graphs, Isomorphic Graph, Paths, Cycles and Connectivity, Eulerian and Hamiltonian Graph, Shortest Path Problems, Representation of Graph (Adjacency and Incidence Matrices), Planar Graph, Graph Coloring, Networks Flows, Matching. Introduction to Combinatory, Fundamental Principles, Factorial Notations, Permutation and Combinations, Pigeonhole Principle, Binomial Theorem, Multimonial Co-efficient, Recurrence Relations, Generating Functions, Interface between Combinatory and Computer Sciences.

Module 5 [8L]: Stochastic Process
Definition and examples of stochastic process, Poisson processes, Random walk, Markov chain; Discrete time Markov chain: Definition and examples, Classification of states, Stationary probability, Finite Markov chain, Transition probability and transition matrix**.**

Books:

1. Introduction to Graph Theory by Douglas B. West, Prentice Hall India.
2. Numerical Methods for Scientific and Engineering Computation by S. R. K. Iyengar and R. K. Jain, Mahinder Kumar Jain, New Age International.
3. Engineering Mathematics by BS Grewal.
4. Discrete Mathematics by S Sarkar

CS13106	Computational Logic	2-0-0	2

Module 1 [8L] Propositional logic, syntax of propositional logic, semantics of propositional logic, truth tables and tautologies, tableaus, soundness theorem, finished sets, completeness theorem. Inference in Propositional Logic.

Module 2 [8L] Predicate logic, syntax of predicate logic, free and bound variables, semantics of predicate logic, graphs, tableaus, soundness theorem, finished sets, completeness theorem, equivalence relations, order relations. Inference in Predicate Logic.

Module 3 [8L] Knowledge Representation: WordNet, BabletNet and Concept Net as Knowledge representation tools.
APPLICATIONS / CASE STUDY -- *Development of a Financial Advisor using First Order Predicate Logic, Semantic Web as Ontology*.

Books:

1. Mathematical Logic and Computability by Jerome Keisler and H. Joel Robbin, McGraw-Hill International Editions, 1996
2. Computational Complexity by Papadimitriou. C. H., Addison Wesley, 1994.
3. Logic for Computer Science: Foundations of Automatic Theorem Proving by Gallier, J. H., 1986.

For B.Tech (ECE)

EC13101	Data Structure & Algorithms	3-0-0	3

Module 1 [8L]: Introduction

Concept and classifications of Data Structures, Concepts of Abstract definition of Data Types, Concept of Time and Space complexity, Asymptotic Notations.

Module 2[12L]: Stack, Queue, Linked List

Abstract definition (ADT), applications in various domains of computer science.

Stack: Representation, elementary operations and applications such as infix to postfix, postfix evaluation, parenthesis matching, Multi-stack, recursion using stack.

Queue: Simple queue, operations, circular queue, dequeue, priority queue.

Linked list: Linear, circular and doubly linked list, operations.

Module 3 [10L]: Tree and Graph

ADT, terminology, operations and applications in various domains of computer science.

Tree: Classifications of trees, Binary Tree, Representation, Binary Tree Traversal, Threaded Binary Tree: operations, Heap tree (Max, Min), Binary Search tree: operation.

Graph: Representations, Graph Traversal: BFS, DFS, Topological Sort.

Module 4[10L]: Sorting and Searching

Sorting: Selection Sort, Bubble Sort, Quick Sort, Merge Sort, Heap Sort, Radix Sort, Searching: Linear and Binary Search.

Hashing – Direct-address tables, open addressing, hash functions.

Books:

1. Data Structures Using C by Aaron M. Tenenbaum, Y. Langsam, Moshe J. Augenstein.
2. Data structures and Algorithms with Object oriented design paterns in C++ by Bruno R. Preiss.
3. Data Structures and Program Design in C by Robert L. Kruse
4. Fundamental of data Structure in C by E. Horowitz, S. Sahni and S. Anderson-Freed.
5. Data Structures and Algorithms by A. V Aho, J. D Ullman and J. E Hopcroft, Addison Wesley.

Fourth Semester

CS14101	Computer Networks	3-0-0	3

Prerequisite: Data Communications (CS 13102)

Module 1[11L]: Internet Protocol
Network layer services, IP, ICMP, IGMP, ARP, RARP, DHCP, routing, multicast routing, router. IPv6: Why IPv6? Basic protocols, extensions and options, support for QoS, security, neighbour discovery, auto-configuration, routing. Changes to other protocols. Routing layer issues, ISPs and peering, BGP, IGP, Routing mechanisms: Queue management, packet scheduling. MPLS, VPNs.

Module 2[10L]: Transport Layer
Transport layer services, UDP, TCP, Socket Programming. New transport layer Protocols, congestion control, TCP extensions for high-speed networks, transaction-oriented applications. SCTP, DCCP.

Module 3[10L]: Application Layer
Application layer protocols: SNMP, HTTPS, PGP, Multimedia networking, streaming stored audio and video, real-time protocols, DNS and issues, other naming mechanisms, overlay networks, p2p networks, web server, Firewalls, IDS, Unified threat Management System, Network Access Control.

Module 4[5L]: QoS issues in networks, Wireless Networks, WSNs, MANETs, VANETs.

Books:

1. Computer Networking: A Top-Down Approach Featuring Internet by J. F. Kurose and K. W. Ross, 3/e, Pearson Education.
2. Data Communications and Networking by Behrouz A. Forouzan, Fifth Edition, 2013
3. Data and Computer Communications by William Stallings, Eighth Edition, 2012
4. Computer Networks, A systems Approach by Peterson L.L. & Davie B.S, 3/e, Harcourt Asia, 2003.
5. Computer Networks by Andrew S. Tanenbaum, 3/E, PHI, 1996.

CS 14201	Computer Networks Laboratory	3-0-0	3

Practical: Protocol simulation; Socket programming; Program development for ftp, SNMP, SMTP, etc; Exercises in network programming;

Experiment 1: Implementation of basic Client Server program using TCP Socket (Eg. Day time server and client).
Experiment 2: Implementation of basic Client Server program using UDP Socket.
Experiment 3: Implementing a program with TCP Server and UDP Client.
Experiment 4: Implementation of TCP Client Server program with concurrent connection from clients.
Experiment 5: Implementing fully concurrent application with a TCP server acting as a directory server and client programs allowing concurrent connection and message transfer (Eg. Chat system).
Experiment 6: Fully decentralized application like a Peer to Peer system. This program is to implement without a designated Sever as in the case of experiment 5.
Experiment 7: Experiments with open source firewall/proxy packages like iptables,ufw, squid etc.
Experiment 8: Experiments with Emulator like Netkit, Emulab etc.
Experiment 9: Experiments with Simulator like NS2, NCTU NS etc.

Books:

1. Unix Network Programming – Networking APIs: Sockets and XTI by W. Rıchard Stevens, Volume 1, 2nd Edition, Pearson Education, 2004.
2. Unix Network Programming – Inter process Communications by W. Rıchard Stevens, Volume 2, 2nd Edition, Pearson Education, 2004.
3. Linux Socket Programming by Example by Warren W. Gay, 1st Edition, Que Press, 2000.
4. Beej's Guide to Network Programming by Brian Hall, http://beej.us/guide/bgnet/
5. Java Network Programming by Elliotte Rusty Harold, 3rd Edition, O'Reilly, 2004.

CS14102	Operating System	3-0-0	3

Module 1 [7L]: Introduction and Process Management: Introduction and need of operating system, layered architecture, logical structure of operating system, OS services, kernel, system calls, firmware, BIOS, bootloader. Process model, creation, termination, states transitions, hierarchy, context switching, process implementation, process control block, basic system calls, Linux and Windows. **Threads:** Threads - processes versus threads, threading, kernel and user level threads, thread usage, benefits, and multi-threading.

Module 2[8L]: Inter-Process Communication; Introduction to message passing, race condition, critical section problem, mutual exclusion with busy waiting, disabling interrupts, lock variables, strict alteration, Peterson's solution, TSL instructions, sleep and wakeup calls, Semaphore, monitors. Classical IPC problems. **Process scheduling:** Process scheduling - basic concepts, classification, CPU and I/O bound, CPU scheduler - short, medium, long-term, dispatcher. Scheduling - preemptive and non-preemptive, static and dynamic, Priority, Co-operative & Non-cooperative, Scheduling algorithms - FCFS, SJFS, Shortest Remaining Time, round robin, priority scheduling, multilevel queue scheduling, multilevel feedback queue scheduling, fair share scheduling.

Module 3[7L]: Deadlock: System model, resource types, deadlock problem, methods for deadlock handling, detection. Deadlock prevention, avoidance, recovery from deadlock. **Memory Management:** Memory management - concepts, functions, logical and physical address space, address binding, degree of multiprogramming, swapping, static & dynamic loading. Memory allocation schemes - first fit, next fit, best fit, worst fit and quick fit. Free space management - bitmap, link list/free list, buddy's system, memory protection and sharing, relocation and address translation.

Module 4[7L]: Virtual Memory: Virtual Memory - concept, virtual address space, pure paging scheme. Segmentation, segmentation with paging scheme, hardware support and implementation details, memory fragmentation, demand paging, pre-paging, page fault frequency, thrashing. Page replacement algorithms - optimal, MRU, LRU, Belady's anomaly, design issues for paging system. Page size, separate instruction and data spaces, shared pages, cleaning policy, TLB. Inverted page table, I/O interlock, program structure, page fault handling. Basic idea of MM in Linux.

Module 5[7L]: File System and Storage: File System - concepts, naming, attributes, operations, types, structure. File organization and access (Sequential, Direct, Index and Sequential) methods. Memory mapped files, directory structures – file system mounting, file sharing, path name, directory operations. Overview of file system in Linux and windows. Allocation of Disk space, Input/output subsystems - concepts, functions/goals, input/output devices- block and character. Spooling, disk structure and operation, disk attachment, disk storage capacity. Disk scheduling algorithm need & type. Introduction to RAID system.

Books:

1. Operating System Concepts by A. Silbersehatz and J. L. Peterson, Wiley.
2. Operating System by Dhamdhere, TMH.
3. Operating Systems by W. Stalling,

CS14202	Operating System Laboratory	2-0-0	2

Theory: Unix system programming fundamentals and system calls.

Practical:

1. Linux shell programming, Inter process communication-Pipes, semaphores, Shared memory and Message passing Loading executable programs into memory and execute System Call implementation-read(), write(), open () and close().
2. Multiprogramming-Memory management- Implementation of Fork(), Wait(), Exec() and Exit() System calls.
3. Implementation of algorithms: scheduling and memory management skills.
4. File system implementation-demand paging - page fault exception – page replacement policy.
5. Implementation of Synchronization primitives -Semaphore, Locks and Conditional Variables Build Networking facilities – Mailbox.

References:

1. Operating Systems by Gary J. Nutt, Pearson Education, 3/e, 2004.
2. Understanding the Linux Kernel by Daniel P Bovet , Marco Cesati, O'Reilly Media, (3/e), 2005

CS14103	Design and Analysis of Algorithms	3-0-0	3

Module 1[10L]: Introduction – Properties of an algorithm, Algorithm analysis, Computational Complexities – Time and Space complexities, Growth of functions, Big-oh, Big-omega, Big-theta, small-oh, small-omega notations. Concept of upper and lower bound (Best, average, and Worst case analysis). Master's theorem, Recurrence relation and computation of complexities.
Divide-and-Conquer – The philosophy behind the divide-and-conquer, Analyzing Divide-and-Conquer algorithms – recursion tree technique, substitution method. Example problems – Merge sort, Maximum sum subarray, Strassen's Matrix multiplication.

Module 2[9L]: Analysis of searching and sorting algorithms using recurrence relation, Medians and Order Statistics. Multi-Way Search Tree: B-Tree, B+ Tree, Height-balanced tree: AVL Tree.

Module 3[10L]: Greedy Algorithm – The idea. Example problems – fractional knapsack problem, activity selection problems, Huffman coding. Analysis. **Dynamic Programming –** The idea. Designing the equation. Bottom-up and Top-down approach. Example problems – rod cutting, coin change, matrix-chain multiplication, longest common subsequence, Kadane's algorithm. Knapsack problem **–** 0/1, integer. **Overview of Backtracking:** N-queen problem, graph coloring problem, **Overview of Branch-and-Bound.**

Module 4[8L]: Review and complexity analysis of graph traversals **–** DFS, BFS. Disjoint-set. Detecting cycle in a graph. **Shortest-path problems –** Single source shortest path – Bellman-Ford, Dijkstra. All pair shortest path – Floyd-Warshall. **Spanning Tree –** Definition, Minimum Spanning-tree algorithm – Prim, Kruskal.

Books:

1. Introduction to Algorithms by Cormen, Leiserson, Rivest, Stein, Prentice-Hall.
2. Fundamentals of Computer Algorithms by Ellis Horowitz, Sartaj Sahni
3. Algorithm Design - John Kleinberg.

CS 14203	Design and Analysis of Algorithms Laboratory	0-0-2	1

Following Experiments will be implemented in the Design and Analysis Algorithm. In each of the experiment, students should write the algorithms followed by the implementation in any of his/her preferred choice of programming language.

1) Heap Sort and Quick Sort.
2) Huffman Coding.
3) Matrix-chain multiplication
4) Longest Common Subsequence.
5) Knapsack problems (All variations).
6) Graph traversals (DFS, BFS, IDDFS).
7) Single-source Shortest path algorithms (Bellman-ford and Dijkstra)

CS14104	Computer Organization and Architecture	3-0-0	3

Module 1 [9L]: Introduction to Advance Micro processor family starting from 8086 onwards to modern processors. Architecture of 8086; BUS concepts and organization, multiplexing and demultiplexing of Buses, addressing modes, basic instruction formats (including three, two, one and zero addressing instruction); Bus organization and concept of memory segmentation. (Simple programming exercise as class assignment), concept of I/O operations and memory mapped I/O.

Module 2 [9L]: Basic organization of the CPU and block level description of the functional unit from execution point of view, complete instruction execution, concept of Fetch, Decode and Execution cycle with the help of timing diagram. Data Representation – Basic formats, fixed and floating point; ALU design, data path concepts, Basic idea of floating point arithmetic. **Control Unit**: Basic concept, Hardwire control and micro programmed control - Block diagram and operation.

Module 3 [9L]: Pipeline: Basic concepts, instruction pipelines – pipeline structure, multistage pipeline, pipeline performance parameters, pipeline hazards.

Module 4 [9L]: Memory: Computer memory system overview, memory hierarchy; cache memory - types and operations. Concept of L1 and L2 cache in computer systems.

Books:

1. Advanced Microprocessors and Peripherals by Ray, Ajoy Kumar, and Kishor M. Bhurchandi, McGraw-Hill,
2. Computer organization & Architecture – Designing for Performance by William Stallings, Pearson Education.
3. Computer Architecture and Organization by J. P. Hayes, McGraw Hill.
4. Computer System Architecture by Morris Mano, Pearson.
5. Computer Organization and Design – The Hardware/Software Interface by D. A. Patterson and J. L. Hennessy, 4th Ed., Morgan Kaufmann.

CS14105	Software Engineering	3-0-0	3

Module 1[9L]: Introduction: The software engineering discipline-evaluation and impact, Programs vs. software products, Why study of software engineering, Emergence of software engineering, Notable changes in software development practice, Computer system engineering.
Software life cycle: Life Cycle Models: Classical waterfall model, Iterative waterfall model, Prototype model, Evolutionary model, Spiral model, RAD model, comparison of different life cycle models.
Agile: Concept and design.

Module 2[9L]: Software project management: Responsibilities of project manager, Project planning, Metrics for project size estimation, Project estimation techniques, Empirical estimation techniques, COCOMO: A heuristic estimation techniques, Staffing, Risk management, Software configuration management. **Requirements analysis and specification:** Requirements gathering and analysis, Software requirement specification (SRS): Contents of the SRS Document, Functional Requirements, Traceability, Characteristics of a Good SRS Document, IEEE 830 guidelines, overview of formal system development techniques. **Software design:** Good Software Design, Cohesion and coupling, Control Hierarchy: Layering, Control Abstraction, Depth and width, Fan-out, Fan-in, Software design approaches, object oriented vs. function oriented design.

Module 3[9L]: Function-oriented software design: Overview of SA/SD methodology, Structured analysis, Data flow diagram, Extending DFD technique to real life systems, Structured design, detailed design, Design review. **Overview of Object Oriented Concepts:** Key Concepts Unified Modelling Language (UML), UML Diagrams, Use Case Diagram, Sequence Diagram, Activity Diagram, State Diagram and Class Diagram. **User interface design:** Characteristics of a good user interface, User Guidance and Online Help, Mode-based Vs Mode-less Interface, Types of user interfaces, Component-based GUI development, User interface design methodology: GUI design methodology, Task and object modeling, Selecting a metaphor, Interaction design and rough layout, User interface inspection. **Coding and testing:** Coding, Code review, Testing, Testing in the large vs. testing in the small, Unit testing, Black- box testing, Debugging, Program analysis tools, Integration testing, System testing, Some general issues associated with testing, Test driven development, testing tools, Introduction to Agile software development and DevOps.

Module 4[9L]: Software reliability and quality management: Software reliability, Statistical testing, Software quality, Software quality management system, ISO 9000, SEI capability maturity model, Personal software process (PSP), Six sigma, Software quality & Metrics**. Computer aided software engineering:** Case and its scope, Case environment, Case support in software life cycle, Other characteristics of case tools, Towards second generation case tool, Architecture of a case environment. **Software maintenance:** Characteristics of software maintenance, Software reverse engineering, Software maintenance processes model, Estimation maintenance cost. **Software reuse:** Basics issues in any reuse program, Reuse approach, Reuse at organization level.

Books:

1. Fundamentals of Software Engineering by Rajib Mall, PHI.
2. Software Engineering- Practioner Approach by Pressman R, McGraw Hill.
3. Software Engineering Concepts by Richard Fairley, Tata McGraw Hill.

Reference:

4. An integrated approach to Software Engineering by Jalote Pankaj, Narosa
5. Software Engineering by Somerville, Pearson
6. Software Design by Budgen, Pearson

CS14106	Microprocessor and Microcontroller	3-0-0	3

Module 1 [9L]: Introduction to Microprocessor, Microcontroller, Microcomputer; 8085 Microprocessor Architecture, Pin Description, Bus concept and organization, Multiplexing and Demultiplexing of Buses; Static and Dynamic RAM, ROM, Memory map; Signals and Timings, Classification of Instructions, Instruction Format, Instruction Set, Addressing Modes.

Module 2[9L]: Assembly Language Programming and Debugging – Simple Assembly Programming, Directives used in Assembly Language, Counter and Time delay, Stack organization and implementation, Macros and Subroutines; Debug and Testing of Assembly Language Programs. Interrupts - Types, Applications and Handling; 8259 Programmable Interrupt Controller.

Module 3[9L]: Interfacing with 8085 Microprocessor – Interfacing of Simple input/output devices (Switches, LEDs); 8255 Programmable Peripheral Interface; 8254 Programmable Interval Timer; 8279 Keyboard/Display Controller; 8251 USART; Memory Interfacing. Serial Interface - RS232C and RS422A; Parallel Interface.

Module 4[9L]: 8051 Microcontroller – Introduction of 8051 family; Block diagram description of AT89C51; Internal Architecture - System Clock and Oscillator Circuits, CPU Registers, SFRs, Memory Map, I/O Ports. Simple program and application development.

Books:

1. Microprocessor Architecture, Programming and Applications with the 8085 by Ramesh S. Gaonkar, Penram Publishers
2. The 8051 Microcontroller & Embedded Systems using Assembly and C by Muhammad Ali Mazidi, D. MacKinlay, Pearson Education.
3. Introduction to Microprocessors by Aditya P. Mathur, Tata McGraw Hill

Reference:

4. Microprocessors and Interfacing by Douglas V. Hall, Tata McGraw Hill.
5. The 8051 Microcontroller – Architecture, Programming and Applications by Kenneth J. Ayala, Penram Publishers.
6. Microcomputers and Microprocessors – The 8080, 8085 and Z80 Programming by John Uffenbeck.

CS14204	Computer System Design Laboratory	0-0-2	1

Example List of Experiments:

1. Assembly language programming of 8051
2. Timer programming of 8051 using status check
3. Timer programming of 8051 using interrupts
4. External interrupts programming of 8051
5. LCD interfacing to 8051 – project
6. Study of current microcontrollers e.g. PIC, ATmega, AVR, Arduino, ARM, Raspberry Pi
7. Motor speed control using microprocessor/microcontroller
8. Project: Real-time system design using existing microcontrollers (e.g. PIC, ATmega, AVR, Arduino, ARM, Raspberry Pi)

References:

1. The x86 Microprocessors by Lyla B. Das, Pearson Education.
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C by Muhammed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mc Kinlay, Pearson Education.
3. Data Sheets of Respective Microcontrollers as updated.
4. Microprocessor Architecture, Programming and Applications with the 8085 by Gaonkar, Penram International.

Fifth Semester

CS15101	Artificial Intelligence	3-0-0	3

Module 1 [10L]: Basic Concepts: Foundations of Artificial Intelligence – the four approaches to AI. Intelligent Agents – Agents and Environments, Rationality, Nature of Environments, Structure of Agents. **Solving Problems by Searching:** Problem-Solving Agents, Searching for Solutions, Uninformed Search Strategies, Heuristic Search Strategies, Heuristic Functions.
Beyond Classical Search: Local Search Algorithms and Optimization Problems, Local Search in Continuous Spaces, Searching with Nondeterministic Actions. Introduction to Adversarial Search.

Module 2[6L]: Logical Agents: Knowledge-Based Agents, Logic, Propositional Logic, Propositional Theorem Proving, Effective Propositional Model Checking, Agents Based on Propositional Logic.

Module 3 [7L]: Classical Planning: Definitions of Classical Planning. Algorithms for Planning as State-Space Search. Planning Graphs. Other Classical Planning Approaches. Analysis of Planning Approaches. **Planning and Acting in the Real World:** Time, Schedule and Resources, Hierarchical Planning, Planning and Acting in Nondeterministic Domains, Multi-agent Planning.
Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Reasoning with Default Information.

Module 4 [7L]: Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, Exact Inference and Approximate Inference in Bayesian Networks. Relational and First-order Probability Models. **Probabilistic Reasoning over Time:** Time and Uncertainty, Inference in Temporal Models, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Keeping Track of Many Objects. **Making Decisions:** Making Simple Decisions – Combining Beliefs and Desires, Utility Theory, Utility Functions, Multi-attribute Utility Functions, Decision Networks, Decision-Theoretic Expert Systems. Sequential Decision Problems. Value Iteration, Policy Iteration. Partially Observable MDPs. Decisions with Multiple Agents.

Module 5[6L]: Fuzzy Logic: Crisp Sets V/s Fuzzy Sets, Fuzzy Functions, Fuzzy Logic and Fuzzy Inference Systems, Type-2 Fuzzy Sets, Intuitionistic Fuzzy Sets based sentiment Analysis.
APPLICATIONS /CASE STUDY– *Match Making for Indian Matrimony, Fuzzy Expert System for Sleep Disturbance, Fuzzy Logic based Air Conditioner, Solving Reviewer Assignment Problem using Fuzzy Functions, Time-Series Forecasting*
Rough Sets: Introduction, Indiscernibility, Set Approximations, properties of Rough Sets, Rough Membership, Reducts.
APPLICATIONS / CASE STUDY- *Development of Part of Speech Tagger for Hindi Language using Rough Sets***.**

Books:

1. Artificial Intelligence by E. Rich and K. Knight, TMH, 2nd Ed., 1992.
2. Principles of AI by N. J. Nilsson, Narosa Publ. House, 1990.

Reference:

3. Artificial Intelligence by P. H. Winston, Pearson Education, 3rd Edition, 2000
4. Fuzzy Logic with Engineering Applications by T. J.Ross, Third Edition, John Wiley.

5. Rule Based Expert Systems by M. Sasikumar, S. Ramani, Narosa Publishing House, 1994.
6. Principles of Soft Computing by Sivandandam, Deepa, Wiley Publications. 2nd Edition.

CS15102	Advanced Algorithms	3-0-0	3

Module 1[5L] String Matching: Introduction to string-matching problem, Naïve algorithm, Rabin Karp, complexity analysis.

Module 2 [9L]: NP-Hard, NP-Complete : Universal Turing Machine**,** NP-Hard and NP complete problems: The Cook-Levin Theorem, The Class P and NP, Reducibility and NP-completeness, Independent Set (IS) problem, Hamiltonian Path problem, 3-Color (Graph coloring with 3 colors) problem and their proof of NP-Completeness. Problems beyond NP-SPACE, NSPACE.

Module 3[5L]:Approximation algorithms: Introduction, Approximation algorithm for The Vertex Cover Problem, Traveling salesman problem (TSP), knapsack, bin packing.
Module 4 [5L] Probabilistic Algorithms: Numerical probabilistic algorithms, Las Vegas and Monte Carlo algorithms, Game-theoretic techniques, Applications on graph problems.

Module 6[12L]: Optimization Algorithms
Linear Programming [2L]: Objective Function, Slack & Surplus Variables, Formulating problems as linear programs, The simplex algorithm.
Heuristic Algorithms[3L]: Heuristic Function, heuristic based algorithms viz. Best First Search, A* Algorithm.
Metaheuristic Algorithms[7L]: Design Implementation and Applications of Genetic Algorithm, ACO, PSO Algorithm.

Books:
1. Introduction to Algorithms by T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, MIT Press.
2. Fundamentals of Computer Algorithms by Ellis Horowitz, Sartaj Sahni
3. Algorithm Design - John Kleinberg.

CS15103	Database Management System	3-0-0	3

Module 1[8L]: Introduction and ER Model

Overview of a DBMS - Purpose of Database Systems; View of Data; Data Models; DDL; DML; File Systems V/s DBMS, advantages and disadvantages of DBMS, Database Administrator; Database Users; Overall System Structure; Entity-Relationship Model: Basic Concepts, Design Issues, Mapping Constraints, Keys, ER-Diagram, Weak Entity Sets, Extended ER-Diagram, Mapping of ER-Schema to Tables.

Module 2[8L]: Relational Model and SQL

Relational Model Concepts: Structure of Relational Databases, Relational Algebra, Extended Relational-Algebra Operations, Modification of the Database, Views; Integrity Constraints: Domain Constraints, Referential Integrity, Structured Query Language(SQL); Basics of query processing, Assertions, Triggers constraints representation in SQL.

Module 3[8L]: Data Dependencies & Normalization

Formal and informal measures of database design, Relational Database Design: Decomposition, Functional Dependencies, Normalization, FDs Implication, Closure and its correctness, 1NF, 2NF, 3NF and BCNF, Dependency Preservation Property.

Module 4[8L]: Transaction and Concurrency Control & Recovery basics:

Transactions and Concurrency Control: Transaction Concepts, Transaction State, Concurrent Executions, Serializability, Recoverability, Lock-Based Protocols, Deadlock Handling; File Organization & Query Processing: File Organization, Organization of Records in Files, Log based recovery.

Module 5[4L]: Introduction to Recent Database Models: Object Oriented Database, Mobile Databases, Distributed Databases, spatial Databases.

Books:

1. Database System Concepts by Abraham Silberschatz, Henry F. Korth and S. Sudarshan, 6th Ed, McGraw Hill.
2. Fundamentals of Database Systems by Ramez Elmasri, Shamkant B. Navathe, Elmasri, PEARSON
3. Database Management Systems by R. Ramakrishnan, J. Gehrke, McGraw Hill, 2004
4. Transaction Processing, Concepts and Techniques by J. Gray and A. Reuter, Morgan Kauffman, 1994.
5. Principles of Database Systems by J. D. Ullman, Galgotia
6. Han, J. and Kamber, M., “Data Mining: Concepts and Techniques”, 2nd Ed., Morgan Kaufmann.
7. Ray Chhanda, “Distributed Database Systems”, Pearson.
8. Date, C. J, “An Introduction to Database Systems”, 8th Ed., Pearson.

CS15104	Parallel and Distributed Systems	3-0-0	3

Module 1[8L]: Introduction; Need; Parallelism in uniprocessors systems; Pipeline-MIMD/SIMD, Distributed systems Versus Parallel systems, Models of distributed Systems-Happened Before and Potential Causality Model, Models based on States.

Module 2[10L]: Distributed algorithms and applications, Clock synchronization algorithms;-Logical clocks, Vector clocks, Verifying clock algorithms, Direct dependency clocks. Fault Tolerance; Fault tolerant, termination detection algorithms and leader election algorithms.

Module 3[10L]: Parallel algorithms: prefix sum computation, matrix multiplication; Ranking, Searching, Traversal and Sorting; multi-threaded programming, p-Threads. Programming models-I (data parallel, task parallel, shared memory, distributed memory- Message Passing): Message passing interface (MPI), Communication Types- Block and Non-blocking, Buffered and Non-buffered; OpenMP programming.

Module 4[8L]: Co-processors parallel systems, GPGPU, CUDA Kernels and Threads, CUDA devices memories, Blocks, Threads and indexes. OpenCL programming, CUDA vs OpenCL.

Books:

1. Introduction to Parallel Computing, by Kumar, Grama, Gupta and Karypis, Benjamin Cummings Publishing Co., 2nd Ed., 2003.
2. Parallel Programming in C with MPI and OpenMP by M. J. Quinn.
3. Program Massively Parallel Processors: A Hands on Approach by David Kirk.
4. Heterogeneous computing with OpenCL by Benedict Gaster and Lee Howes

References:

1. H. Attiya and J. Welch, Distributed Computing: Fundamentals, Simulation and Advanced Topics, McGraw Hill
2. Parallel Programming in OpenMP by Dror Mayden at all.
3. Parallel Programming with MPI by Petter S. Pacheco.
4. Using MPI: Portable Parallel Programming with the Message-Passing Interface, by William Gropp, Ewing Lusk, and Anthony Skjellum, 2nd Ed., 1999.
5. CUDA GPU Gems 3 by Hubert Nguyen.

CS15105	Theory of Computation	3-0-0	3

Module 1[12L] Finite Automata and Regular Expression (RE): Introduction to Automata theory, Regular Expressions, Formal Definition of Regular Expression, Algebraic laws for Regular expressions, Kleen's Theorem, Closure Properties, DFA, NFA, epsilon-NFA, Mealy machine, Moore Machine, Minimization of FA, Grammar, Regular Grammars, equivalence of regular language, DFA and NFA, Pumping Lemma for regular Languages. Application of Pumping Lemma, Closure properties of Regular Languages.

Module 2[12L] Context Free Grammar (CFG) and Context Free Language (CFL): Language, Context free grammar, Simplification of CFG, Normal Form of CFG, left recursion, left factoring, Basic Push down automata (PDA)**,** DPDA, NDPDA, Construct of PDA from CFG, Construction of CFG Equivalent to PDA, Two stack PDA. Removing null productions, unit productions and λ-productions, Pumping lemma for CFLs.

Module 3[10L] Turing Machine: Ambiguity in Languages, inherently ambiguous language, Chomsky Hierarchy of Languages**,** Basic Turing machine, DTM, NDTM, Variation of TM, Multidimensional Turing Machine, Programmable Turing Machine, Linear Bounded Automata.

Module 4[6L] Compiler: Compilation process and phases of compiler, Lexical Analysis and Syntax Analysis.

Books:

1. Introduction to Automata Theory, Languages and Computation by J. E. Hopcroft, R. Motwani and J. D. Ullman, Pearson, 2001.
2. Elements of the Theory of Computation by H. R. Lewis and C. H. Papadimitriou, Prentice Hall, 1997/Pearson 1998.
3. Introduction to the Theory of Computation by M. Sipser, Thomson Asia, 1997.
4. Automata and Computability by D. C. Kozen, Springer-Verlag, 1997.
5. Compilers : Principles, Techniques, & Tools by Alfred V. Aho, Ravi Sethi, D. Jeffrey Ulman, Monica S. Lam, 2nd Edition
6. Introduction to Languages And The Theory of Computation by John Martin

Sixth Semester

CS 16101	Cloud Computing	3-0-0	3

Module 1 [9L]: Introduction

Definition of Cloud Computing: Defining a Cloud, Cloud Types – NIST model, Cloud Cube model, Deployment models, Service models, Cloud Reference model, Characteristics of Cloud Computing, Benefits and advantages of Cloud Computing; Cloud Architecture: A brief introduction on Infrastructure, Platforms, Virtual Appliances, Communication Protocols, Applications, Connecting to the Cloud by Clients; Services and Applications by Type: IaaS, PaaS, SaaS, IDaaS and CaaS.

Module 2 [9L]: Use of Platforms in Cloud Computing

Concepts of Abstraction and Virtualization: Virtualization technologies, Load Balancing and Virtualization, Hypervisors, Machine Imaging, Porting of applications in the Cloud; Concepts of Platform as a Service; Use of PaaS Application frameworks; Use of Google, Amazon and Microsoft Web Services;

Module 3 [9L]: Cloud Infrastructure

Cloud Management: Features of network management systems, Monitoring of an entire cloud computing deployment stack – an overview with mention of some products, Lifecycle management of cloud services (six stages of lifecycle); Cloud Security: Cloud security concerns, Security boundary, Security service boundary, Overview of security mapping, Security of data, Identity management.

Module 4 [9L]: Concepts of Services and Applications

Service Oriented Architecture: Basic concepts of message-based transactions, Protocol stack for an SOA architecture, Event-driven SOA, Enterprise Service Bus, Service catalogs; Applications in the Cloud: Concepts of cloud transactions, functionality mapping, Application attributes, Cloud service attributes, System abstraction and Cloud Bursting, Applications and Cloud APIs; Cloud-based Storage: Cloud storage definition – Manned and Unmanned; Webmail Services: Cloud mail services including Google Gmail, Mail2Web, Windows Live Hotmail, Yahoo mail.

Books:

1. Cloud Computing Bible by B. Sosinsky, Wiley India
2. Mastering Cloud Computing by R. Buyya, C. Vecchiola and S. T. Selvi, McGraw Hill
3. Cloud computing: A practical approach by A. T. Velte, TMH
4. Cloud Computing by Miller, Pearson
5. Building applications in cloud: Concept, Patterns and Projects by Moyer, Pearson

CS16201	Cloud Computing Laboratory	0-0-2	1

1. How to create a datacenter with one host and run one cloudlet on it.
2. How to create two datacenters with one host and a network topology each and run two cloudlets on them.
3. How to create two datacenters with one host each and run cloudlets of two users with network topology on them.
4. How to create two datacenters with one host each and run two cloudlets on them.
5. How to create two datacenters with one host each and run cloudlets of two users on them.

6. How to create scalable simulations.
7. How to pause and resume the simulation, and create simulation entities (a Datacenter Broker in this example) dynamically.
8. How to create simulation entities (a Datacenter Broker in this example) in run-time using a global manager entity (Global Broker).
9. How to create a datacenter with one host and a network topology and run one cloudlet on it.

CS16102	Image Processing	3-0-0	3

Module 1[9L]: Introduction

Background; Digital Image Representation; Fundamental steps in Image Processing; Elements of Digital Image Processing; Digital Image Formation: A Simple Image Model, Geometric Model-Basic Transformation (Translation, Scaling, Rotation), Perspective Projection, Sampling & Quantization - Uniform & Non uniform; Mathematical Preliminaries: Neighbor of pixels, Connectivity, Relations, Equivalence & Transitive Closure, Distance Measures, Arithmetic/Logic Operations, Fourier Transformation, Properties of The Two Dimensional Fourier Transform, Discrete Fourier Transform, Discrete Cosine & Sine Transform.

Module 2[9L]: Image Enhancement

Spatial Domain Method, Frequency Domain Method, Contrast Enhancement -Linear & Nonlinear Stretching, Histogram Processing; Smoothing - Image Averaging, Mean Filter, Low-pass Filtering; Image Sharpening. High-pass Filtering, High-boost Filtering, Derivative Filtering, Homomorphic Filtering; Enhancement in the frequency domain - Low and high pass filtering.

Module 3[9L]: Image Restoration

Degradation Model, Discrete Formulation, Algebraic Approach to Restoration - Unconstrained & Constrained; Constrained Least Square Restoration, Restoration by Homomorphic Filtering, Geometric Transformation - Spatial Transformation, Gray Level Interpolation.

Module 4[9L]: Image Segmentation

Point Detection, Line Detection, Edge detection, Combined detection, Edge Linking & Boundary Detection - Local Processing, Global Processing via The Hough Transform; Thresholding - Foundation, Simple Global Thresholding, Optimal Thresholding; Region Oriented Segmentation - Basic Formulation, Region Growing by Pixel Aggregation, Region Splitting & Merging.

Books:

1. Digital Image Processing by Gonzalves, Pearson.
2. Digital Image Processing by Jahne, Springer.
3. Digital Image Processing & Analysis by Chanda & Majumder, PHI.
4. Fundamentals of Digital Image Processing by Jain, PHI.

CS16103	Cryptography and Network Security	3-0-0	3

Module 1 [9L]: Algebra: Group, cyclic group, cyclic subgroup, field, probability. Number Theory: Fermat's theorem, Cauchy's theorem, Chinese remainder theorem, primality testing algorithm, Euclid's algorithm for integers, quadratic residues, Legendre symbol, Jacobi symbol etc.

Module 2 [9L]: Cryptography and cryptanalysis, Classical Cryptography, substitution cipher,

different type of attack: CMA, CPA, CCA etc. Shannon perfect secrecy, OTP, Pseudo random bit generators, stream ciphers andRC4.

Module 3 [9L]: Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis; One-way function, Trapdoor one-way function, Public key cryptography, RSA cryptosystem, Diffie-Hellman key exchange algorithm, Elgamal Cryptosystem; Cryptographic hash functions, Secure hash algorithm, Message authentication, digital signature, RSA digital signature, Elgamal digital signature.

Module 4 [9L]: IKE and IPSec; SSL/TLS; E-mail Security and PGP.

Books:

1 Cryptography and Network Security by Behrouz A. Forouzan and Debdeep Mukhopadhyay, Second edition, Tata McGraw Hill, 2011.
2 Cryptography and Network Security Principles and practice by W. Stallings, 5/e, Pearson EducationAsia, 2012.
3 Cryptography: Theory and Practice by Stinson. D., third edition, Chapman & Hall/CRC, 2010.
4 Elementary Number Theory with applications by Thomas Koshy, Elsevier India, 2005.

CS16104	Machine Learning	3-0-0	3

Module 1 [9L]: Introduction to Machine Learning: Introduction, Examples of Various Learning Paradigms, Perspectives and Issues, Version Spaces, Finite and Infinite Hypothesis Spaces, PAC Learning, VC Dimension.

Module 2 [9L]: Supervised Learning: Decision Trees: ID3, Classification and Regression Trees, Regression: Linear Regression, Multiple Linear Regression, Logistic Regression, Support vector machines: Linear and Non-Linear, Kernel Functions, K-Nearest Neighbors

Module 3 [9L]: Ensemble Learning: Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: *Random Forest Trees*, Boosting: *Adaboost*, Stacking.
Unsupervised Learning: Introduction to clustering, Hierarchical: *AGNES, DIANA*, Partitional: *K-means clustering, K-Mode Clustering*, Expectation Maximization, Gaussian Mixture Models.
Probabilistic Learning: Bayesian Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks

Module 4 [9L]: Neural Networks and Deep Learning: Perceptron, Multilayer Perceptron, Representational limitation and gradient descent training. Multilayer networks and back propagation. Hidden layers and constructing intermediate, distributed representations. Over fitting, learning network structure, recurrent networks.
Re-inforcement Learning: Q-Learning**.**

Books:

1 Introduction to Machine Learning by Ethem Alpaydin, MIT Press, PHI, 3rd Edition 2014.
2 Applied Machine Learning by M. Gopal, TMH.
3 Machine Learning by Tom Mitchell, McGraw Hill, 3rd Edition,1997.
4 Foundations of Machine Learning by Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, MIT Press, 2012.
5 Artificial Intelligence and Machine Learning by Vinod Chandra and Anand Harindra, PHI**.**

6 Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, The MIT Press, 2012.
7 Data Mining –Concepts and Techniques by Jiawei Han and Micheline Kambers and Jian Pei, 3rd edition, Morgan Kaufman Publications, 2012.

CS16105	Data Analytics	3-0-0	3

Module 1 [9L]: Analysis of unstructured data, recommender system, Spark, R, R-HADOOP. **Descriptive Statistics:** Introduction to the course**,** Descriptive Statistics, Probability Distributions.

Module 2 [9L]: Introduction to Hadoop Distributed File System, The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization.

Module 3 [9L]: Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.

Module 4 [9L]: Collaborative Filtering, Social networking analysis. **Inferential Statistics:** Inferential Statistics through hypothesis tests, Permutation & Randomization Test. **Regression & ANOVA:** Regression, ANOVA(Analysis of Variance).

Books:

1. Hadoop: The Definitive Guide by Tom White, Third Edit on, O'reily Media, 2012.
2. Big Data Analytics by Seema Acharya, Subhasini Chellappan, Wiley 2015.
3. Intelligent Data Analysis by Michael Berthold, David J. Hand, Springer, 2007.
4. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses by Michael Mineli, Michele Chambers, Ambiga Dhiraj, Wiley Publications, 2013.

List of Elective Subjects

CS1*111	Software Project Management	3-0-0	3

Module 1[9L]: Definition – components of SPM – challenges and opportunities – tools and techniques – managing human resource and technical resource – costing and pricing of projects – training and development – project management techniques

Module 2[9L]: Monitoring & measurement of SW development – cost, size and time metrics – methods and tools for metrics , Classifying software measures, determining what to measure, applying the framework, Software measurement validation .

Module 3[9L]: Quality in SW development – quality assurance – quality standards and certifications – the process and issues in obtaining certifications – the benefits and implications for the organization and its customers – change management.

Module 4[9L]: The risk issues in SW development and implementation – identification of risks – resolving and avoiding risks – tools and methods for identifying risk management, SPM Tools & case study on SPM.

Books:

1. Software Engineering: A Practitioner's Approach by Pressman, MGH, 8th Ed.
2. Software Engineering Project Management by Richard H. Thayer, John Wiley & Sons, 2nd edition.
3. Software Project Management by Royce, Walker, Pearson Education.
4. Software Project Management in Practice by Pankaj Jalote, Pearson Education Inc.
5. Software Project Management by Kelker, S. A., Prentice Hall.

CS1*112	Software Testing	3-0-0	3

Module 1[9L]: Software Verification and Validation- Introduction, Verification, Method of Verification, Validation, Level of Validation, Principle of testing, context of testing in producing software, White Box testing- Definition, Static testing, Structural testing, and Black box testing.

Module 2[9L]: Integration Testing- Scenario Testing, Defect bash, System and acceptance testing- functional, non-functional testing, Performance testing- methodology, tools & Process. Other Important type of testing's used in IT Industry: Regression Testing, Internationalization Testing, Enabling testing, Locale Testing, Language testing, Localization testing, Ad-hoc testing- Overview, Buddy testing, Pair Testing, Exploratory Testing, Iterative testing Agile and Extreme Testing.

Module 3[9L]: Testing of object-oriented systems: Introduction, Primer on object–oriented software's and Differences in object oriented testing. Usability and Accessibility Testing. Test planning, Test Management, Test Process and reporting,

Module 4[9L]: Software Test Automation- Scope of Automation, Design and Architecture of automation, Process Model for Automation, Test metrics and measurement- Type of Metrics, Project Metrics, Productivity Metrics, Progress Metrics, Release Metrics.

Books:

1. Software testing: Principles and Practice by Srinivasan D., Gopalswami R. Pearson Education.
2. Software Testing: Principles by M G Limaye Tata McGraw Hill.
3. Software Engineering by Sommerville Pearson Education.
4. Software Engineering – a practitioner approach by Roger Pressman, 7e, Tata McGraw Hill.
5. Software Testing by Yogesh Singh, TMH

CS1*113	Software Architecture	3-0-0	3

Module 1[6L]: Creation of the Software Architecture, Viewpoint Considerations of the Software Architect & Terminology, Views and Viewpoints Application, Software Architecture Principles, System Structures, Patterns and Anti-Patterns Research Assignment.

Module 2[6L]: Software Construction: Application Development and Visualization, Requirements Validation, Programming Patterns, Selecting the Right Development Methodology, Software Construction, Technology Platforms

Module 3[6L]: Components, Frameworks and Tools: Client Programming and User Experience (UX), Selection of Infrastructure Components, Client, Server and Storage Technologies, Modeling, Workflow, Creation of a Generic Architecture, Database Programming, Database Design and Considerations

Module 4[6L]: Service Network : Asynchronous and Synchronous Distributed Computing, SOA, Applying SOA Principles, Messaging, XML and B2B, Application and Service Management, Connecting the Sum of the Parts

Module 5[6L]: Architectural Process, Methods and Artifacts: Modeling, Applying Design Patterns, Capture and Trace of Software Architecture, Code Quality Analysis, Design Patterns Selection and Application.

Module 6[6L]: Architecture Throughout the Lifecycle: Software Architecture Governance, Working with other Architects, Application Service Transition, SDLC - What it means to the Software Architect, Formal Release Policy, Professional Growth and Mentoring.

Books:

1. Software Architecture in Practice, Len Bass, Paul Clements, Rick Kazman.
2. Documenting Software Architectures: Views and Beyond Paul Clements, Felix Bachmann, Len Bass, David Garlen, James Ivers, Reed Little, Robert Nord, Judith Stafford.

CS1*114	Software Modeling and Design	3-0-0	3

Module 1[8]: Overview of Traditional Software Process Models; Software Requirements and Design Principles, Requirements Analysis, Elicitation and Specification, Effective Modular Design.

Module 2[8]: Agile Software Process: Agile Manifesto, Plan Driven Approach vs Agile Development Process; Agile Methods: Extreme Programming (XP), Adaptive Software Development, Scrum, Crystal, FDD, Lean and DSDM, Agile Practices: Extreme Programming, Continuous Delivery, Refactoring, Working with Legacy Code, Test-Driven Development.

Module 3[8]: Software Configuration Management (SCM): The SCM process, Software Risk Management: Software risks; Software Risk: Risk identification, assessing risk impact, Risk mitigation, monitoring and refinement.

Module 4[8]: Software Quality: Attributes; Specifications; Standards; Assurance and Reliability; Quality through the Lifecycle; ISO/IEC 12207; Quality Management Systems, ISO 9000; Quality Achievement; Quality Control; Quality Preservation; Process Improvement, ISO/IEC 15504 and CMMI.

Module 5[8]: Software Metrics, Process, Product and Project Metrics; Software Measurement; Metrics for Software Quality; Software Project Estimation; Empirical Estimation Model.

Books:

1. R.S. Pressman, Software Engineering - A Practitioner's Approach, McGraw Hill, 7th Edition.
2. Ian Sommerville, "Software Engineering", 9th Edition, Pearson Education, Inc., publishing as Addison-Wesley, 2011

CS1*115	Computer Graphics	3-0-0	3

Module 1[9L]: Introduction and organization of an interactive graphics system, Graphics hardware and display devices; Basic raster graphics algorithms for drawing primitives; Scan conversion; Region filling; Anti-aliasing.

Module 2[9L]: Coordinate Systems - representations, homogenous coordinates, object, camera, world, and screen coordinate system, changing coordinate systems. Transformations - affine transformations, translation, rotation, scaling in homogenous coordinates, matrix representations and their applications. Viewing and Hidden Surface Removal - its importance in rendering, z buffer algorithm, clipping, culling.

Module 3[9L]: Projections - orthographic and perspective projection. Lighting and Shading - light sources, normal computation, reflection models, flat and smooth shading, Introduction to Textures and Mapping - Rendering Techniques - slicing, volume rendering, iso-surface extraction, ray casting, multi resolution representations for large data rendering.

Module 4[9L]: Introduction to Curves Surfaces (Bezier, splines) and Meshes - structured and unstructured, video games and computer animation, GUI: concepts of window programming, open GL programming in Windows / Linux environments.

Books:

1. D. Hearn and M. P. Baker, Computer Graphics, McGraw Hill
2. Z. Xiang and R. A. Plastock, Shaum's Outline of Computer Graphics, McGraw Hill

CS1*116	Computer Vision	3-0-0	3

Module 1 [9L]: Introduction and overview, pinhole cameras, radiometry terminology. Sources, shadows and shading: Local shading models- point, line and area sources; photometric stereo. Color: Physics of color; human color perception, Representing color; A model for image color; surface color from image color.

Module 2 [9L]: Linear filters: Linear filters and convolution; shift invariant linear systems-discrete convolution, continuous convolution, edge effects in discrete convolution; Spatial frequency and fourier transforms; Sampling and aliasing; filters as templates; Normalized correlations and finding patterns. Edge detection: Noise; estimating derivatives; detecting edges. Texture: Representing texture; Analysis using oriented pyramid; Applications; Shape from texture. The geometry and views: Two views.

Module 3 [9L]: Stereopsis: Reconstruction; human stereo; Binocular fusion; using color camera.

Module 4 [9L]: Segmentation by clustering: Human vision, applications, segmentation by graph theoretic clustering. Segmentation by fitting a model, Hough transform; fitting lines, fitting curves.

Books:

1. David A Forsynth and Jean Ponce, Computer Vision- A modern approach, Pearson education series, 2003.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, Digital image processing and computer vision, Cengage learning, 2008.
3. Schalkoff R. J., Digital Image Processing and Computer Vision, John Wiley, 2004.

CS1*117	Pattern Recognition	3-0-0	3

Module 1[9L]: Introduction: Machine Perception, Pattern Recognition Systems, The Design Cycle, Learning and Adaptation. Bay's Decision Theory: Bayes Decision Theory, Minimum Error rate Classification, Classifiers, Discriminant functions and Decision Surfaces, Normal Density, Discriminant functions for the Normal Density, Bayes Decision Theory for Discrete features

Module 2[9L]: Maximum Likelihood and Bayesian Parameter Estimation: Maximum Likelihood Estimation, Bayesian Estimation, Bayesian Parameter Estimation, Gaussian Case and General Theory.Hidden Markov models; Non Parametric Techniques: Density Estimation, Parzen Windows, K- Nearest Neighbor Estimation, Nearest Neighbour rule, Metrics and Nearest Neighbour Classification, Fuzzy Classification, *k*-Means Clustering, Self-Organizing Maps.

Module 3[9L]: Linear Discriminant Functions: Linear Discriminant Functions and Decision Surfaces, Generalized Discriminant Functions, The two-category linearly separable case, Minimizing the perceptron criterion function, relaxation procedures, non- separable behaviour, Minimum Squared- Error procedures. Support vector machines, Algorithm-independent machine learning-Bias and Variance, Bootstrapping-Adaboost Algorithm, Boosting, Bagging

Module 4[9L]: Multi-Layer Neural Networks: Feed-forward Operation, Classification, Back – propagation Algorithm, Error Surfaces, Back-propagation as Feature mapping, Radial Basis Function Networks, Decision trees: Axis-parallel, Oblique, Impuritymeasures; Graphical Model,

Books:

1 R. O. Duda, P. E. Hart and D. G. Stork, Pattern classification, John Wiley & Sons, 2002.
2 C. M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.
3 V. N. Vapnik, The Nature of Statistical Learning Theory, Springer, 2000.

4 N. Cristianini and J. Shawe-Taylor, An Introduction to Support Vector Machines, Cambridge University Press, 2000.

CS1*118	Compiler Design	3-0-0	3

Module 1 [9L]: Introduction to Compiling**:** Compilers – Analysis of the source program – Phases of a compiler – Cousins of the Compiler – Grouping of Phases – Compiler construction tools – Lexical Analysis – Role of Lexical Analyzer – Input Buffering – Specification of Tokens.

Module 2 [9L]: Syntax Analysis**:** Role of the parser –Writing Grammars –Context-Free Grammars – Top Down parsing – Recursive Descent Parsing – Predictive Parsing – Bottom-up parsing – Shift Reduce Parsing – Operator Precedent Parsing – LR Parsers – SLR Parser – Canonical LR Parser – LALR Parser.

Module 3 [9L]: Intermediate code generation: Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples);
Introduction– Principal Sources of Optimization – Optimization of basic Blocks – DAG representation of Basic Blocks - Introduction to Global Data Flow Analysis

Module 4 [9L]: Runtime Environments – Source Language issues – Storage Organization – Storage Allocation strategies – Access to non-local names – Parameter Passing, Error detection and recovery. Code Optimization: Introduction, basic & flow graph. Peephole optimization

Books:

1. Aho, Sethi and Ullman, Compiler Principles, Techniques and Tools, Pearson Education.
2. Holub, Compiler Design in C, PHI.

CS1*119	Web Programming	3-0-0	3

Module 1 [9L]: Internet and its architecture, Client Server Networking - Creating an Internet Client, Application Protocols and http, Presentation aspects html, CSS and Java script, Creating a web server, Serving Dynamic Content- CGI – overview of technologies like PHP – applets – JSP. Implementation

Module 2[9L]: Web server architecture, Programming threads in C, Shared memory synchronization, Performance measurement and workload models. Comparison using existing benchmarks.

Module 3[9L]: Web development frameworks – Detailed study of one open source web framework - Ruby Scripting, Ruby on rails – Design, Implementation and Maintenance aspects.

Module 4[9L]: Service Oriented Architecture – SOAP. Web 2.0 technologies. – AJAX. Development using Web2.0 technologies. Introduction to semantic web.

Books:

1. Dave Thomas, with Chad Fowler and Andy Hunt. Programming Ruby: The Pragmatic Programmer's Guide (3/e), Pragmatic Programmers, May 2008.
2. Balachander Krishnamurthy and Jennifer Rexford. Web Protocols and Practice: HTTP/1.1,

Networking Protocols, Caching, and Traffic Measurement (1/e), Addison Wesley Professional, 2001

CS1*120	VLSI Design	3-0-0	3

Module 1 [9L]: Introduction: Introduction to IC Technology – MOS, PMOS, NMOS, CMOS & BiCMOS, Basic Electrical Properties: Basic Electrical Properties of MOS and BiCMOS Circuits: IdsVds relationships, MOS transistor threshold Voltage, gm, gds, Figure of merit ωo; Pass transistor, NMOS Inverter, Various pull ups, CMOS Inverter analysis and design, Bi-CMOS Inverters.

Module 2 [9L]: VLSI Circuit Design Processes: VLSI Design Flow, MOS Layers, Stick Diagrams, Design. Rules and Layout, 2 µm CMOS Design rules for wires, Contacts and Transistors Layout Diagrams for NMOS and CMOS Inverters and Gates, Scaling of MOS circuits.

Module 3[9L]: Gate Level Design: Logic Gates and Other complex gates, Switch logic, Alternate gate circuits, Time delays, Driving large capacitive loads, Wiring capacitance, Fan – in, Fan – out, Choice of layers.

Module 4 [9L]: Data Path Subsystems: Subsystem Design, Shifters, Adders, ALUs, Multipliers, Parity generators, Comparators, Zero/One Detectors, Counters. Array Subsystems: SRAM, DRAM, ROM, Serial Access Memories. **Programmable Logic Devices:** PLAs, FPGAs, CPLDs, Standard Cells, Programmable Array Logic, Design Approach, Parameters influencing low power design. CMOS Testing: CMOS Testing, Need for testing, Test Principles, Design Strategies for test, Chip level Test Techniques.

Books:

1. Essentials of VLSI circuits and systems – Kamran Eshraghian, Eshraghian Dougles and A. Pucknell, PHI, 2005 Edition
2. CMOS VLSI Design – A Circuits and Systems Perspective, Neil H. E Weste, David Harris, Ayan Banerjee, 3rd Ed, Pearson, 2009.
3. CMOS logic circuit Design – John .P. Uyemura, Springer, 2007.
4. Modern VLSI Design – Wayne Wolf, Pearson Education, 3rd Edition, 1997.

CS1*121	Embedded System	3-0-0	3

Module 1[8L]: INTRODUCTION TO EMBEDDED SYSTEMS
Embedded system model – embedded standards – block diagrams – powering the hardware - embedded board using von Neuman model. EMBEDDED processors: ISA architecture models – application specific ISA models – general purpose ISA models – instruction level parallelism.

Module 2[7L]: REAL-TIME ENVIRONMENT 9 Hours
Real-time computer system requirements – classification of real time systems – simplicity – global time – internal and external clock synchronization – real time model. Real – time communication – temporal relations – dependability.

Module 3[7L]: REAL-TIME OPERATING SYSTEMS 9 Hours
Real –time communication – event triggered – rate constrained – time triggered. Inter

component communication – task management – dual role of time – inter task interactions – process input/output – agreement protocols – error detection.

Module 4[7L]: SYSTEM DESIGN 9 Hours
Scheduling problem - static & dynamic scheduling – system design – validation – time–triggered architecture.

Module 5[7L]: CASE STUDY ON PROGRAMMING EMBEDDED SYSTEMS 9 Hours
Building the blinking LED program-eCos Examples-Embedded linux examples-Extending functionality-optimization techniques.

Books:

3. Embedded system architecture by Tammy Noergaard, 2nd Edition , Elsevier, 2012
4. Real–Time systems – Design Principles for distributed Embedded Applications by Hermann Kopetz, 2nd Edition, Springer 2011
5. Programming Embedded Systems-With C and GNU Development Tools by Michael Barr, Anthony Massa, 2nd Edition, O'Reilly Media, 2009.
6. Embedded Systems – Architecture Programming and Design by Raj Kamal, Tata McGraw Hill, 2nd Edition, 2011.

CS1*122	Real Time Systems	3-0-0	3

Module 1[10L]: Introduction to Real-time systems, Issues in Real-time Systems, Real-time System Components, Classification of Real-time systems and Real-time tasks. Misconceptions about real-time computing. Real-time System requirements: Speed, Predictability, reliability, adaptability. Specification of timing constraints

Module 2[10L]: Real-time scheduling: Requirements and Issues, Terminology, modeling, Introduction static and dynamic scheduling schemes, cyclic scheduling, priority driven scheduling of periodic tasks, schedulability tests.

Module 3[10L]: Aperiodic task scheduling: fixed priority server/non-server based scheduling algorithms. Practical factors/overheads.

Module 4[10L]: Task Synchronization: Need and priority inversion problem, Priority Inheritance protocol, priority ceiling protocol and stack-based priority ceiling protocol for fixed priority preemptive system. Introduction to multiprocessor real-time systems, problems and issues. An overview of a real-time operating system.

Books

2. J.W.S.Liu: Real-Time Systems, Pearson Education Asia.
3. Rajib Mall, "Real-Time Systems: Theory and Practice," Pearson, 2008.
4. S.T.Lavi, A.K.Agrawala: Real-time system Design, McGraw Hill.
5. P.A.Laplante: Real-time Systems Design and Analysis, An Engineer's Handbook, IEEE Press.
6. P.D.Laurence, K.Mauch: Real-time Microcomputer System Design, An Introduction, McGraw Hill.
7. Krishna and Shin, "Real-Time Systems," Tata McGraw Hill. 1999.

CS1*123	Deep Learning	3-0-0	3

Module 1[9L] Introduction to Deep Learning: Why Deep Learning? What is a neural network? Three reasons to go Deep, Your choice of Deep Net, An old problem: The Vanishing Gradient.

Module 2[9L] Deep Learning Models: Restricted Boltzmann Machines, Deep Belief Nets, Convolutional Networks, Recurrent Nets. **Additional Deep Learning Models**: Autoencoders, Recursive Neural Tensor Nets, Deep Learning Use Cases.

Module 3[9L] Introduction to various CNN Architectures: VGG16, VGG19, Alex Net, Google Net, ResNet, etc. **Sequence Models:** RNN, LSTM, BURT, Image captioning, visual question answering, Generative Adversarial Networks (GAN) models, Deep Reinforcement Learning and Network Visualization.

Module 4[9L] Deep Learning Platforms and Software Libraries: What is a Deep Learning Platform? H2O.ai, Dato GraphLab, What is a Deep Learning Library? CPUs, GPUs, TPUs, PyTorch, Theano, Caffe, TensorFlow, Dynamic vs Static computation graphs

Books:

1. Neural Networks and Deep Learning: A Textbook Book by Charu C. Aggarwal
2. Deep Learning: A Practitioner's Approach Book by Adam Gibson and Josh Patterson
3. Deep Learning by Aaron C. Courville, Ian Goodfellow, and Yoshua Bengio

CS1*124	Natural Language Processing	3-0-0	3

Module 1[9L]: Basic Concepts: Importance of Natural Language Processing, Ambiguity of Language, Lexical Resources, Word counts, Zipf's Law, Collocations and Concordance, An overview of Information Theory – Entropy, Joint entropy and conditional entropy, Mutual information, Noisy Channel model, Kullback-Leibler divergence, Cross entropy, The entropy of English Language, Perplexity.
Linguistic Essentials: Parts of Speech and Morphology, Phrase Structure – Phrase Structure Grammars, Arguments and Adjuncts, X' Theory, Phrase Structure Ambiguity, Semantics and Pragmatics. Corpus-based work – Tokenization, Morphology, Sentences, Markup schemas, Grammatical Tagging.

Module 2[9L]: Collocations: Frequency, Mean and Variance, Hypothesis testing: t test, Hypothesis testing of differences, Pearson's chi-square test, Likelihood ratios, Mutual Information, The notion of collocation.
n-gram Models over Sparse Data: Bins - Forming Equivalence Classes, n-gram models, Buildin n-gram models, Statistical Estimators – MLE, Laplace Law, Lidstone Law, Jeffreys-Perks Law, Held-out estimation, Cross-validation, Good-Turing estimation. Combining Estimators - Simple linear interpolation, Katz's backing-off, General linear interpolation.
Word Sense Disambiguation: Overview of Supervised and Unsupervised Learning, Pseudowords, Supervised Disambiguation, Dictionary-based Disambiguation, Unsupervised Disambiguation, Word Sense.
Lexical Acquisitions: Evaluation Measures, Verb Subcategorization, Attachment Ambiguity, Selection Preferences, Semantic Similarity.

Module 3[9L]: Part-of-Speech Tagging: Concept of Markov Models and Hidden Markov Models, Information source of Tagging, Markov Model Taggers – probabilistic model, Viterbi Algorithm, variations, Hidden Markov Model Taggers, Transformation-based Learning of tags – Transformations, The Learning Algorithm, Tagging Accuracy and uses of Taggers.
Probabilistic Parsing: Probabilistic Context Free Grammars. The probability of a string. Parsing for Disambiguation, Treebanks, Tree probabilities and Derivational probabilities, Phrase structure grammars and Dependency grammars, Evaluation, Building Parsers – Search methods, use of the Geometric Mean.

Module 4[9L]: Statistical Alignment: Text alignment, Word alignment, Statistical Machine Translation. **Clustering:** Hierarchical Clustering – Single-link and Complete-link, Group-average agglomerative, Non-hierarchical Clustering – K-means, EM Algorithm.
An overview of Information Retrieval: Common design features, Evaluation measures, Probability Ranking Principle, Vector Space Model, Term Distribution Models, Latent Semantic Indexing, Discourse segmentation.
Text Categorization: Decision Trees, Maximum Entropy Modelling, Perceptrons, k Nearest Neighbor Classification.

Books:
1. Foundation of Statistical Natural Language Processing by Christopher D. Manning

CS1*125	Advanced Topics in DBMS	3-0-0	3

Module 1 [12L]: Review of DBMS concepts
Formal review of relational database, Applications of DBMS, FDs Implication, Closure and its correctness, 3NF and BCNF, Minimal Cover of Functional Dependency, Decomposition and synthesis approaches, Review of relational algebra and SQL, Basics of query processing. Dependency preservation, Lossless join decomposition, Multi-values dependency, 4NF, Join dependency.

Module 2[9L]: Transactions, Serializability and Concurrency Control
Concurrent executions, Serializability view and conflict serializability, Recoverability, Lock based protocols, Timestamp based protocols, Validation based protocols, Deadlock handling, Insert and delete operations, Failure classification, Recovery and atomicity, Log based recovery, Shadow paging, Buffer management, Remote backup systems.

Module 3[10L]:
Distributed Databases [5L]
Homogeneous and heterogeneous databases, Distributed transactions, Commit protocols, Concurrency control in distributed databases.
Hashing and Indexing, Inverted Index, Query Optimization [5L].

Module 4[5L]: Advanced Data Types and Advanced applications
Time in databases, Spatial and geographic databases, Multimedia databases, Knowledge discovery and data mining, Data mining functionalities, Classification of data mining systems, Data warehousing concepts, Slicing, Dicing schemas.

Books:
1. Database System Concepts by Abraham Silberschatz, Henry F. Korth and S. Sudarshan,

6th Ed, McGraw Hill.
2. Fundamentals of Database Systems by Ramez Elmasri, Shamkant B. Navathe, Elmasri, PEARSON
3. Database Management Systems by R. Ramakrishnan, J. Gehrke, McGraw Hill, 2004
4. Transaction Processing, Concepts and Techniques by J. Gray and A. Reuter, Morgan Kauffman, 1994.
5. Principles of Database Systems by J. D. Ullman, Galgotia
6. Han, J. and Kamber, M., "Data Mining: Concepts and Techniques", 2nd Ed., Morgan Kaufmann.
7. Ray Chhanda, "Distributed Database Systems", Pearson.
8. Date, C. J, "An Introduction to Database Systems", 8th Ed., Pearson.

CS1*126	Advanced Data Structures & Algorithms	3-0-0	3

Module 1[9L]: Overview: Binary search tree (BST), **AVL Tree:** insertion and deletion of a node (all Rotations).

Graph Theory:

Amortized Cost Analysis: Aggregate Analysis, Accounting Method, and Potential Method

Module 2 [9L]: Red-Black Trees: Insertion and all Rotations, deletion and all Rotations, Complexity Analysis of all operations, Comparison between AVL tree and RB tree, When to use what?

Binary heap, Binomial Heaps: insertion and deletion of elements, finding maximum and minimum element.

Fibonacci Heaps: insertion and deletion of elements, finding maximum and minimum element.

KdTree: Construction of KdTree, Searching the tree.

Module 3 [9L]: Computational Geometry: Line segments and determine whether any pair of segments intersects. Plane Sweep Techniques with its applications, Convex Hull problem (Extreme point algorithm, incremental algorithm, divide & conquer approach).

Randomized algorithms: Use of probabilistic inequalities in analysis, applications using examples. Randomized approximation algorithms for MAX 3-SAT, Randomized Divide-Conquer, Quick sort. Randomized Hashing.

Module 4 [9L]: Recent Algorithms.

Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, Introduction to Algorithms, Prentice hall.
2. Jon Kelinberg and Eva Tardos, Algorithm Design, Pearson
3. Data Structures Using C Second Edition Reema Thareja
4. Franco P. Preparata and Michael Ian Shamos, Computational Geometry An Introduction, Springer- Verlag

CS1*127	Advanced Computer Networks	3-0-0	3

Module 1[8L]: Review of Networking Concept, MAC Layer Issues: MAC Layer for high speed LANs, MANs, VLAN. Fast Access Technologies, IP addressing basics, Private IP addressing, NAT and PAT.

Module 2[10L]: Wireless LANs and mobile network, Wireless 802.16 (WI-MAX), Bluetooth (802.15.1), Medium Access CSMA/CA, Hidden Terminal and exposed Terminal Problems, Ad-hoc Network and routing protocols.
Router User Interface, Connecting to a Router, Setup Model, Command Line Interface, CLI Prompts, Layer 2 Switching: Meaning, Devices, STP, LAN Types and working on switches and Basic commands, VLANs: VLAN Basics, Membership, Frame Tagging, VLAN Trunking Protocol, Access List: Intro to Access List, Standard Access List, Telnet Access, Extended Access List.

Module 3[10L]: Queuing Theory, TCP flavors: Tahoe, Reno, New-Reno, TCP-SACK, TCP-RED, and TCP-Vegas. Transport protocol for real time (RTP), Quality of Services: Integral Services, Resource reservation Protocol (RSVP), Differentiated Services. Routing and Multicast, Structure of internet: Autonomous System, Inter-domain routing: OSPF and RIP, Inter domain Routing: BGP, Multicasting: Group Management (IGMP).

Module 4[8L]: Peer-to-Peer and Overlay Network. Concept of overlays, Unstructured Overlays: Overlay Network, Internet Traffic Modeling, P2P Network, Gnutella, Concepts of Distributed Hast Table, Structured Overlays: Chord, CAN, Pastry.

Books:

1. Computer Networks: A System Approach, by Peterson and Davie, 5th Edition Morgan Kauffman, 2011.
2. Computer Networking: Top Down Approach, by kurose and Ross, 6th Ed. Pearson, 2011.
3. Cisco Certified Networking Associate Study Guide, By Todd Lammle, Sixth Edition, Wiley Publications.

CS1*128	Internet of Things	3-0-0	3

Module 1[8L]: Overview- IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management.

Module 2[8L]: Reference Architecture- IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.

Module 3[8L]: IoT Data Link Layer & Network Layer Protocols- PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART,Z-Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP.

Module 4[8L]: Transport & Session Layer Protocols - Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT.

Module 5[8L]: Service Layer Protocols & Security: Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC 802.15.4, 6LoWPAN, RPL, Application Layer

Books:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1 st 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)", 1 st Edition, VPT, 2014.

CS1*129	Mobile Computing	3-0-0	3

Module 1[9L]: INTRODUCTION: Mobile Computing – Mobile Computing Vs wireless, Networking – Mobile Computing Applications – Characteristics of Mobile computing-Structure of Mobile Computing Application. MAC Protocols – Wireless MAC Issues – Fixed, Assignment Schemes – Random Assignment Schemes – Reservation Based Schemes.

Module 2[9L]: MOBILE INTERNET PROTOCOL AND TRANSPORT LAYER: Overview of Mobile IP – Features of Mobile IP – Key Mechanism in Mobile IP – route Optimization. Overview of TCP/IP – Architecture of TCP/IP- Adaptation of TCP Window – Improvement in TCP Performance.

Module 3[9L]: MOBILE TELECOMMUNICATION SYSTEM: Global System for Mobile Communication (GSM) – General Packet Radio Service (GPRS) – Universal Mobile Telecommunication System (UMTS).
MOBILE AD-HOC NETWORKS: Ad-Hoc Basic Concepts – Characteristics – Applications – Design Issues – Routing – Essential of Traditional Routing Protocols –Popular Routing Protocols – Vehicular Ad Hoc networks (VANET) – MANET Vs VANET – Security.

Module 4[9L]: MOBILE PLATFORMS AND APPLICATIONS: Mobile Device Operating Systems – Special Constrains & Requirements – Commercial Mobile Operating Systems – Software Development Kit: iOS, Android, BlackBerry, Windows Phone – MCommerce – Structure – Pros & Cons – Mobile Payment System – Security Issues.

Books:

1. Mobile Communications by Jochen H. Schller, Second Edition, Pearson Education, New Delhi, 2007.
2. Introduction to Wireless and Mobile systems by Dharma Prakash Agarval, Qing and An Zeng, Thomson Asia Pvt Ltd, 2005.

CS1*130	Mainframe Technology	3-0-0	3

Module 1[10L]: Mainframe Applications: Characteristics of Mainframe Applications**,** Classes of Mainframe applications, Batch**,** On-line, Interactive, Inter/Intra/Extranet, Network Capabilities, Application Development, High Level Languages, Standard Utilities, Other Utilities.

Module 2[10L]: Mainframe Components: CPUs, Main Storage, Channels, Control Units, Direct Access Storage Device (DASD), Tape Devices, Printers & Card Readers, Terminals, Operating System, System Operation, Maintenance.
OS Components: Features, Virtual Storage, Swapping, Paging, Multiprogramming, Spooling, Sub-Systems, Usage Modes, Batch Processing, Time Sharing Data Sets.

Module 3[10L]: Catalogs, VTOC and DASD labels, Tape Labels, Naming Convention, Generation Data Groups, Data Security, Archiving, Backup.
OS Processing:
Data Set Access, File Organization, Record Organization, Access Strategies, Databases: Concepts, Hierarchical Databases, Network Databases, Relational Databases.
Batch Processing: Jobs, JCL, Job Entry Subsystem (JES), Job Submission, Job Scheduling, Initiators, Job Execution, Output Processing, Scheduling Extensions, Audit Extensions, Output Extensions.

Module 4[6L]: OS TP Monitors and Tools
TP Monitors, SNA/VTAM, CICS/VS, IMS, VM/CMS, TSO

CS1*131	Fog and Edge Computing	3-0-0	3

Module 1[9L]: Fog and Edge Computing Completing the Cloud, Advantages of FEC: SCALE, How FEC Achieves, These Advantages: SCANC, Hierarchy of Fog and Edge Computing, **Addressing the Challenges in Federating Edge Resources.**
Module 2[9L]: Optimization Problems in Fog and Edge Computing, Middleware for Fog and Edge Computing: Design Issues.
Module 3[9L]: Data Management in Fog Computing.
Module 4[9L]: Applications and Issues.

Books:

1. Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama.

CS1*132	Search Engine Optimization	3-0-0	3

Module 1[6L]: Basics for SEO: What is Domain? Basic Knowledge of World Wide Web, Difference between Portal and Search Engines, What is SEO, Types of SEO Techniques, Black hat techniques, White Hat techniques, How Search Engine works.

Module 2[5L]: SEO Research & Analysis, Market Research, Keyword Research and Analysis, Keyword opportunity, Competitors Website Analysis, SWOT Analysis of Website, How to Choose Best Keywords, Tools available for Keyword Research.

Module 3[5L]: Website Design SEO Guidelines: Content Research, Content Guidelines, Content Optimization, Design & Layout, XML Sitemap / URL List Sitemap.

Module 4[5L]: On-page Optimization: The Page Title, Meta Descriptions & Meta Keywords,

Headings, Bold Text, Domain Names & Suggestions, Canonical Tag, Meta Tags, Images and Alt Text, Internal Link Building, The Sitemap, Invisible Text, Server and Hosting Check, Robots Meta Tag, Doorway Pages, 301 Redirects, 404 Error, Duplicate content.

Module 5[5L]: Off-page Optimization: Page Rank, Link Popularity, Link Building in Detail, Directory Submission, Social Bookmark Submission, Blog Submission, Articles, Links Exchange, Reciprocal Linking, Posting to Forums, Submission to Search Engine, RSS Feeds Submissions, Press Release Submissions, Forum Link Building, Competitor Link Analysis.

Module 6[5L]: Analytics: Google Analytics, Installing Google Analytics, How to Study Google Analytics, Interpreting Bars & Figures, How Google Analytics can Help SEO, Advanced Reporting, Webmaster Central & Bing/Yahoo, Open Site Explorer, Website Analysis using various SEO Tools available.

Module 7[5L]: SEO Tools and Reporting: Keyword Density Analyzer Tools, Google Tools, Yahoo / Bing Tools, Rich Snippet Text Tools, Comparison Tools, Link Popularity Tools, Search Engines Tools, Site Tools, Miscellaneous Tools, Google analysis, Tracking and Reporting, Reports Submission, Securing Ranks.

Books:

1. Search Engine Optimization For Flash by Perkins
2. Website Optimization by King

CS1*133	Information Retrieval Techniques and Evaluation	3-0-0	3

Module 1[9L]: Introduction: Basic IR system structure; Retrieval techniques: Boolean retrieval, term-vocabulary, postings-lists, Dictionaries, Entropy of information calculations.

Module 2[9L]: Inverted indices: Preprocessing steps, tokenization, stemming, stop word removal, term weighting; Index Compression: Data Compression Techniques, Huffman Coding, Arithmetic Coding, compressing posting lists.

Module 3[9L]: Models: vector space model, probabilistic model, language models; Evaluation: standard test collection, concept of relevance, precision-recall based metrics, reciprocal rank, DCG; Relevance feedback and query expansion: Rocchio algorithm;Text classification : Naïve Bayes; Text clustering: Flat Clustering, Hierarchical Clustering; XML Retrieval: Basic concepts, Challenges, Evaluation.

Module 4[9L]: Web search: Structure of Web, web graph, Hidden Web, User intent, Web crawl. Link Analysis: Web as a graph, Page Rank, Hubs and Authorities; Sentiment analysis of social networking, Question Answering, Collaborative Searching.

Books:

1. Introduction to Information Retrieval by Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Cambridge University Press. 2008.

CS1*134	Virtual Reality	3-0-0	3

Module 1[8L]: Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environments requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark, 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.

Module 2[8L]: Geometric Modeling: Introduction – From 2D to 3D – 3D space curves – 3D boundary representation, Geometrical Transformations: Introduction, Frames of reference, Modeling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection, Generic VR system: Introduction, virtual environment, Computer environment, VR Technology, Model of interaction, VR Systems.

Module 3[8L]: Virtual Environment: Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Non-linear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system, Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

Module 4[8L]: VR Hardware and Software: Human factors: Introduction, the eye, the ear, the somatic senses, VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems, VR Software: Introduction, Modeling virtual world, Physical simulation, VR toolkits, Introduction to VRML

Module 5[4L]: VR Applications: Introduction, Engineering, Entertainment, Science, Training
The Future: Virtual environment, modes of interaction

Books:

1. Virtual Reality Systems by John Vince, Pearson Education Asia, 2007.

References:

1. Visualizations of Virtual Reality by Adams, Tata McGraw Hill, 2000.
2. Virtual Reality Technology by Grigore C. Burdea, Philippe Coiffet, Wiley Inter Science, 2nd Edition, 2006.
3. Understanding Virtual Reality: Interface, Application and Design by William R. Sherman, Alan B. Craig, Morgan Kaufmann, 2008.

CS1*135	Bioinformatics	3-0-0	3

Module 1[9L]: Molecular Biology and Biological Chemistry: The Genetic Material, Gene structure and Information Content, Protein Structure and Function, The Nature of Chemical Bonds, Molecular Biology Tools – Biomolecular Operations. C-value Paradox, Reassociation Kinetics.

Data Searches and Pairwise Alignments: Dot Plots, Simple Alignments, Gaps – Simple Gap Penalties, Origination and length penalties. Scoring Matrices. Needleman-Wunsch Algorithm. Global and Local Alignment – Semiglobal alignments, Smith-Waterman Algorithm. Database Searches – BLAST, FASTA, Alignment scores and statistical significance of database searches. Multiple Sequence Alignments.

Module 2[9L]: Substitution Patterns: Patterns of Substitutions within Genes, Estimating Substitution Numbers, Variations in Evolutionary Rates between Genes. Molecular Clocks.
Distance-based Methods of Phylogenetics: Molecular Phylogenetics, Phylogenetic Trees – tree reconstruction, rooted and unrooted trees, gene vs species trees, character and distance data. Distance Matrix Methods – UPGMA, Estimation of branch lengths, Transformed distance method, Neighbor's relation method, Neighbor-joining methods. Maximum Likelihood Approaches. Multiple Sequence Alignments.

Module 3[9L]: Character-based Methods of Phylogenetics: Parsimony – Informative and Uninformative sites, Unweighted and Weighted Parsimony. Inferred Ancestral Sequences. Strategies for Faster Searches. Consensus Trees. Tree Confidence – Bootstrapping, Parametric Tests, Comparison of Phylogenetic Methods, Molecular Phylogenetics.
Genomic and Gene Recognition – Prokaryotic Genomes, Prokaryotic Gene Structure. GC Content in Prokaryotic Genomes. Prokaryotic Gene Density. Eukaryotic Genomes. Eukaryotic Gene Structure. Open Reading Frames – Introns and exons. GC Content in Eukaryotic Genomes – CpG islands, Isochores, Codon usage bias. Gene Expression. Transposition. Repetitive Elements. Eukaryotic Gene Density.

Module 4[9L]: Protein and RNA Structure Prediction: Amino Acids, Polypeptide Composition, Secondary Structure – Backbone flexibility, Accuracy of predictions, Chou-Fasman and GOR methods. Tertiary and Quaternary Structure – Hydrophobicity, Desulfide bonds, Active structures. Algorithms for Modeling Protein Folding – Lattice models, Off-lattice models, Energy fuctions and optimizations. Structure Prediction – Comparative modeling, Reverse protein folding.
Proteomics: From Genomes to Proteomes. Protein Classification – Enzyme nomenclature, Families and superfamilies, Folds. Experimental Techniques – 2D electrophoresis, Mass spectrometry, Protein microarrays. Inhibitors and Drug Design. Ligand Screening. X-Ray Crystal Structures. NMR Structures. Empirical Methods and Prediction Techniques. Post-translational Modification Prediction.

Books:
Fundamental Concepts of Bioinformatics, Krane, Raymer.

CS1*136	Quantum Computing	3-0-0	3

Module 1[8L]: Overview of Quantum Computing: Quantum bits – single qubit and multi-qubit systems. Measurements, Quantum Circuits, Bell states, Quantum Teleportation. Quantum Algorithms - Classical computations on quantum computer, Quantum parallelism, Deutsch's Algorithm, Deutsch-Jozsa Algorithm. Experimental Approach - Stern-Gerlach Experiment. Quantum Information.

Module 2[8L]: Overview of Linear Algebra and Quantum Mechanics: Bases, Linear Operators, Pauli Matrices, Inner products, Adjoints and Hermitian Operators, Tensor Products. Operator functions. The commutator and anti-commutator, Polar and singular value decomposition.
Postulates of Quantum Mechanics: State Space, Evolution, Quantum Measurement, Distinguishing Quantum States, Projective and POVM Measurements, Phase, Composite Systems. Superdense coding. Density Operator – Ensembles of quantum states, General properties, Reduced Density operators. Schmidt Decomposition and Purifications. EPR and Bell

inequality.

Module 3[10L]: Quantum Circuits: Single qubit operations, Controlled operations, Measurement, Universal Quantum Gates, Quantum Circuit model of Computation, Quantum System Simulation – Quantum Simulation Algorithm.
Quantum Search Algorithm: Grover's Search Algorithm – oracle, geometric visualization, performance. Quantum Search as a Quantum Simulation. Quantum Counting. Speeding up the solutions of NP-complete problems. Quantum Search of an unstructured database, optimality, Black Box Algorithm Limits.

Module 4[10L]: Physical Realization of Quantum Computers: Conditions for Quantum Computation, Harmonic oscillator, Optical Photon, Optical Cavity Quantum Electrodynamics, Ion Traps, Nuclear Magnetic Resonance. Current trends in implementation –Quantum hardware designed by D-Wave, IBM QX.
Quantum Error Correction, Quantum Information Theory, Quantum Cryptography.

Books:
1. Quantum Computation and Quantum Information, Nielsen, Chuang

CS1*137	Nature-Inspired Computing	3-0-0	3

Module 1 [9L]: Introduction, Some Nature Inspired Solutions, Characteristics of Nature not existing in Traditional Computing, Traditional Computing vs Biological Computing.

Module 2 [9L]: Computations in Nature: Social Insects, Immune System, Evolving Population, Brain etc.

Module 3 [9L]: Evolutionary Intelligence, Collective Intelligence, Social Natural Intelligence. Genetic Algorithm, Ant Colony Optimizations, Bees Algorithm, Bat Algorithm, Paddy Field Algorithm, Cuckoo Search Algorithm, Fire-fly Algorithm etc.

Module 4 [9L]: Recent topics in nature inspired computing.

Books:
1. Nature Inspired Algorithm for Optimization by Raymond Chiong, Springer.
2. Nature Inspired Optimization Algorithms by Xin-She yang, Elsevier.
3. Nature Inspired Metaheuristics Algorithms by Xin-She yang, Luniver Press

CS1*138	Information Theory and Coding	3-0-0	3

Module 1 [9L]: Probability Theory Review, Entropy, Mutual Information, Random Sources, Stochastic Process, Markov Sources, Discrete Finite State Stationary Markov Sources, Entropy Rate, Conditional Entropy

Module 2 [9L]: Noise less coding, Shannon's first fundamental theorem, Discrete memory less channel, Mutual information, Sources with finite memory, Markov sources, Shannon's second

fundamental theorem on coding, Huffman coding, Lempel – Ziv algorithm, Shannon-Fano algorithm.

Module 3 [9L]: Error detecting codes, Hamming distance, Error correcting codes, Repitition codes, Linear block codes, binary cyclic codes, BCH codes, Reed-Soleman codes, Golay codes. Convolution Coding: Code tree, state diagram, Trellis diagram, Maximum-Likelihood decoding ,Viterbi's algorithm, Sequential decoding.

Module 4 [9L]: Network Information theory, Information Theoretic Security, Perfect Secrecy, Shannon's Theorem, Perfectly Secret Codes, Introduction to Computational Security and Pseudo Random Sources

Books:

1. T.M Gover, J.M Thomos,"Elements of Information Theory", Wiley , Edition 2nd
2. Haykins S, "Digital Communications", Wiley
3. D. J. Mackay , "Information Theory, Inference and Learning Algorithms " Cambridge University Press ,Edition 2002
4. J G Proakis, " Digital Communications", Mc Graw Hill.
5. Ballard and C.M.Brown, Computer Vision , Prentice Hall, Englewood Cliffs
6. Roman, S. Coding and Information Theory. New York: Springer-Verlag, 1992

CS1*139	Wireless Network Security	3-0-0	3

Module 1 [10L]: Threats and Security Goals, Network Security Analysis, Information Security Measures, Important Terms relating to Communication Security; Challenges of Broadcast Communication, Security Requirements for Broadcast Applications; Broadcast Network Requirements, IPv-4 vs IPv6,

Module 2 [10L]: The wireless Local Area Network (WLAN): Wireless Transmission Media, WLAN Products and Standards, 802.11 security, IEEE 802.11b/n/g.., Securing WLANs, Countermeasures;
Wireless Application Protocol (WAP): Comparison of the TCP/IP with mobile TCP/IP, OSI and WAP Models, WAP Security Architecture, Marginal Security;
Secure Wireless and Mobile Communications: Security aspects of mobile communications: Security in WLANs, Mobile WANs, Mobile Internet Communications, Wireless Transport Layer Security.

Module 3 [10L]: Bluetooth Technology: Basic specifications, Design specifications, Security architecture, Authentication and encryptions;
Voice over Internet Protocol (VoIP): The Buzz around VoIP, VoIP standards, The rise of VoIP Technology, Technical Issues and Voice network security.

Module 4 [10L]: Hardware Perspectives for End-to-End Security (E2E) in Wireless Applications: Communication - Client-Server versus Peer-to-Peer, Circuit-Switched versus Packet-Switched or Frame-Switched, Unicast versus Broadcast/anycast, LAN-Based versus Wireless-Based Communications,
Transmission Medium, Transmission Nature, Advanced Mobile Phone Services, Internet Telephony, Time Division Multiple Access, GSM, Wideband and narrowband CDMA

Books:

1. S.K. Makki, P. Reiher, K. Makki, N. Pissinou and S. Makki, Mobile and wireless network security and privacy, Springer.
2. R. Nichols and P. Lekkas, Wireless Security: Models, Threats and Solutions, McGrawhill, 2010

CS1*140	Public Key Infrastructure and Trust Management	3-0-0	3

Module 1 [9L]: Asymmetric key cryptography: RSA cryptosystem, RABIN Cryptosystem ElGamal Cryptosystem, message Integrity & Authentication; Random Oracle model, message authentication, Cryptographic hash functions; MD hash families, Whirlpool, SHA-512

Module 2[9L]: Digital Signature; Process and services, attacks on digital signatures, Digital Signature Schemes; Digital certificates and PKIs; Different PKIs: PGP (Pretty Good Privacy): Web of trust, applications; X.509: X.500, Certification Authority (CA), Registration Authority (RA), Root-CA, X.509 Protocols, Simple PKI (SPKI)

Module 3[9L]: Entity Authentication; Passwords and Challenge Response, zero-knowledge and bio-metrics, Key management; security key distribution, Kerberos, Symmetric Key agreement, Public Key Distribution and Hi-jacking, Issues of revocation, Anonymity and Privacy Smartcard integration with PKIs, Trust management systems,

Module 4[9L]: Email Security, PGP and S-MIME, Cloud security through PKI, Application in e-commerce, e-business, e-payment, e-health and mobile applications.

Books:

1. Cryptography and Network Security by Behrouz Forouzan and D. Mukhopadhyay
2. Public Key Infrastructure Overview by Joel Weise, Sun Blue Prints

CS1*141	Advanced Topics in Cyber Security	3-0-0	3

Module 1 [9L]: Introduction
Overview of Public Key Cryptography, Symmetric Cryptography, Digital Signature, Encryption/Decryption Algorithms, Public Key Infrastructure, Internet Key Exchange Protocol

Module 2 [9L]: Elliptic Curve Cryptography
Different types of elliptic curves recommended by NIST and their characteristics, elliptic curve operations, computational hardness's of elliptic curve (ECDLP, ECFP, CDHP, DDHP), elliptic curve digital signature algorithm (ECDSA), elliptic curve Diffie-Hellman protocol, elliptic curve PKI, Security protocols in real life applications (research articles).

Module 3 [9L]: Identity Based Cryptography
Zero knowledge proof system, pairing based cryptography, bilinear mapping, chosen cipher text security models, identity-based encryption, attribute-based encryption, different access control models.

Module 4 [9L]: Attribute Based Encryption
Preliminary quantum mechanics, Quantum algorithms, Mathematical models of quantum

computation, their relationships to each other, and to physical systems; Quantum error correcting codes; Quantum cryptography, Quantum fault tolerance.

Books:

1. Cryptography: Theory and Practice by Douglas Stinson
2. Foundation of Cryptography by Oded Goldreich
3. Physical-Layer Security by Matthieu Bloch and Joao Barros
4. Quantum Computation and Quantum Information by Michael Nielsen and Isaac Chuang

CS1*142	Cyber Forensics	3-0-0	3

Module 1 [9L]: Computer forensics fundamentals, Benefits of forensics, Computer crimes, Computer forensics evidence and courts, Legal concerns and private issues. Understanding digital and cloud forensics.

Module 2 [9L]: Understanding Computing Investigations, Understanding data recovery work station and software, Conducting and investigations.

Module 3 [9L]: Data acquisition- understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, remote network acquisition tools, other forensics acquisitions tools.

Module 4 [9L]: Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, storing digital evidence, obtaining digital hash, reviewing case.

Books:

1. Warren G. Kruse IIandJay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, 2002.
2. Nelson, B, Phillips, A, Enfinger, F, Stuart, C., "Guide to Computer Forensics and Investigations, 2nd ed., Thomson Course Technology, 2006, ISBN: 0-619-21706-5.
3. Vacca, J, Computer Forensics, Computer Crime Scene Investigation, 2nd Ed, Charles River Media

CS1*143	Blockchain Technology	3-0-0	3

Module 1 [9L]: Introduction: Overview of Blockchain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Blockchain, Transactions, Distributed Consensus, Public vs Private Blockchain, Understanding Cryptocurrency to Blockchain, Permissioned Model of Blockchain, Overview of Security aspects of Blockchain, Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

Module 2 [9L]: Understanding Blockchain with Cryptocurrency: Bitcoin and Blockchain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay. Working with Consensus in Bitcoin**:** Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Module 3 [9L]: Understanding Blockchain for Enterprises: Permissioned Blockchain: Permissioned model and use cases, Design issues for Permissioned blockchains, Execute contracts, State machine replication, Overview of Consensus models for permissioned blockchain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems. Enterprise application of Blockchain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Blockchain, Blockchain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Blockchain.

Module 4 [9L]: Blockchain application development: Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

Books:

1. Blockchain: Blueprint for a New Economy by Melanie Swan, O'Reilly, 2015
2. Blockchain: The Blockchain for Beginners-Guide to Blockchain Technology and Leveraging Blockchain Programming by Josh Thompsons
3. Blockchain Basics by Daniel Drescher, Apress; 1st edition, 2017

CS1*144	Software Defined Networking	3-0-0	3

Module 1[8L]: INTRODUCING SDN: SDN Origins and Evolution – Introduction – Why SDN? - Centralized and Distributed Control and Data Planes - The Genesis of SDN.

Module 2 [7L]: SDN ABSTRACTIONS
How SDN Works - The Openflow Protocol - SDN Controllers: Introduction – General Concepts - VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight - Layer 3 Centric - Plexxi - Cisco OnePK

Module 3 [7L]: PROGRAMMING SDN'S: Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing

Module 4 [7L]: SDN APPLICATIONS AND USE CASES: SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3

Module 5 [7L]: SDN'S FUTURE AND PERSPECTIVES: SDN Open Source - SDN Futures - Final Thoughts and Conclusions

Books:

1. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014
2. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013
3. Software Defined Networking with OpenFlow By SiamakAzodolmolky, Packt Publishing, 2013

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