

# Course Syllabi

## Department of Computer Science and Engineering

### CSL101 COMPUTER PROGRAMMING

(3-0-2-8)

#### Contents:

Overview of a computer system, Block diagram and major parts of a computer, history of computer development, introduction to binary, octal, & hexadecimal numbers, ASCII code, different levels of programming languages – machine language, assembly language, high level language; need of operating system, tree structure of storage, introduction to assembler, compiler and interpreter.

Introduction: Flow charts, data types and storage classes, scope of variables, arithmetic operators, assignment, conditional, arithmetic expressions, enumerated data types, decision making, branching, looping, Switch concept, function and parameter passing, recursive functions, macros. Basic programming algorithms: Programs to illustrate basic language constructs in C like - Factorial, Sine/cosine and other mathematical series, Fibonacci series, calculating square-root of a number, calculating GCD of 2 integers (Euclid's method and otherwise), Calculating LCM of 2 integers and similar such programs.

Arrays and applications: Introduction to one dimensional and 2-D array with examples. Representing a polynomial using 1-D array and polynomial operations, Use of 2-D array to represent a matrix and matrix operations. Character arrays (strings): String related functions (strlen, strcpy, strcat, strcmp, reverse etc.) and their function definitions. Searching and Sorting methods: Selection sort, Bubble sort, Insertion sort, Linear and binary search, partitioning an array, merging of 2 sorted arrays. Introduction to "Divide and Conquer" via Mergesort and Quicksort.

Structures and Unions: Basic concept, array of structures and its applications.

Pointers: Introduction (declaration and initialization), pointers and arrays, concept of dynamic memory allocation, use of pointers to represent variable-sized 1-D and 2-D arrays, pointers to structures.

File Management in C: Open, close, read and write operations, Sequential and text files.

#### Text Books:

1. Kerninghan, B.W. and Ritchie, D.M., The C Programming Language, 2<sup>nd</sup> ed., PHI, Delhi, 2012.
2. Balguruswamy, E., Programming in ANSI C, 6<sup>th</sup> ed., Tata McGraw Hill, New Delhi, 2013.

#### Reference Books:

1. Deshpande, P.S. and Kakde, O.G., C and Data Structures, Dreamtech Press, New Delhi, 2009.
2. Dromey, R.G., How to Solve it by Computer, Pearson Education, Delhi, 2008.
3. Gottfried, B.S., Schaum's Outline of Theory and Problems of Programming with C, 2<sup>nd</sup> ed., McGraw Hill, New York, 2007.

### CSL201 DATA STRUCTURES AND PROGRAM DESIGN (3-0-2-8)

#### Contents:

Types and operations, Iterative constructs and loop invariants, Structured programming and modular design, Illustrative examples, recursion, program stack and function invocations including recursion. Overview of arrays and array based algorithms - searching and sorting, Overview of Selection sort, bubble sort and insertion-sort, Divide and Conquer – Merge sort, Quicksort, Binary search, Introduction to Program complexity (Big Oh notation), Recurrence relations. Sparse matrices. Introduction to pointers, scope rules, parameter passing mechanisms – pass by value and pass-by-reference. Structures (Records) and array of structures (records). Database implementation using array of records. Dynamic memory allocation and de allocation. Dynamically allocated single and multi-dimensional arrays. Files, operations on them, examples of using file. Stack, Queues and its operations. Concept of an Abstract Data Type (ADT), Implementation of stacks and queues using both array-based and pointer-based structures. Uses of stacks in simulating recursive procedures/ functions. Applications of stacks and queues. Lists – Self-referential structures, Singly-linked lists, doubly linked lists and circular linked lists. List traversal, insertion, deletion at different positions in the linked lists, concatenation, list-reversal etc. Merge sort for linked lists. Applications of lists in polynomial representation, multi-precision arithmetic, hash-tables etc. Multi linked structures and an example application like sparse matrices. Implementation of priority queues. Trees, binary trees, binary trees- basic algorithms and various traversals. Binary Search Trees (BSTs) and insertion, deletion in BSTs. Height-balanced (AVL) trees, insertion/deletion and rotations. Heaps and heap sort. Multi-way trees and external sorting - Introduction to B-trees and B+ trees. Tries. Applications of the above mentioned trees. Generalisation of trees to graphs – Introduction to DFS, BFS and Topological sort.

#### Text Books:

1. Kruse, R.L., Tondo, C. L. and Leung, B.P., Data Structures and Program Design in C, 2<sup>nd</sup> ed., Pearson Education, Delhi, India, 2013.
2. Horowitz, E., Sahni, S. and Anderson-Freed, S., Fundamentals of Data Structures in C, 2<sup>nd</sup> ed., University Press, Hyderabad, 2012.

#### Reference Books:

1. Kerninghan, B.W. and Ritchie, D.M., The C Programming Language, 2<sup>nd</sup> ed., PHI, Delhi, 2012.
2. Dromey, R.G., How to Solve it by Computer, Pearson Education, Delhi, 2008.

### CSL202 COMPUTER ORGANIZATION

(3-2-0-8)

#### Contents:

Addressing methods, their application in implementation of HLL constructs and data structures, instruction formats, expanding op-code method, subroutine linkage. Instruction sets of ARM, Intel and Motorola Processors. Processing unit, bus architecture, execution of a complete instruction, sequencing of control signals, micro programmed control, microinstruction format, microinstruction sequencing, bit slice concept. Arithmetic, number representations and their operations, design of fast address, signed multiplication, Booth's Algorithm, bit-pair recording, division, floating point numbers and operations, guard bits and rounding.

Main memory organization, various technologies used in memory design, higher order memory design, multi module memories and interleaving, cache memory, concept of cache memory, mapping functions, replacement algorithms.

Input-output organization, I/O mapped I/O and memory mapped I/O, Direct Memory Access, interrupt and interrupts handling mechanisms, device identification, vectored interrupts, interrupt nesting, I/O interfaces, synchronous vs. asynchronous data transfer, I/O channels. Computer peripherals, I/O devices such as video terminals, video displays, graphic input devices, printers, magnetic disk, magnetic tape, CDRom systems.

Introduction to RISC philosophy, Pipelining, Basic concepts in pipelining.

#### Text Book:

1. Hamacher, V.C., Vranesic, Z.G. and Zaky, S.G., Computer Organization, 5<sup>th</sup> ed., Tata McGraw Hill, 2013.

#### Reference Books:

1. Patterson, D.A. and Hennessy, J.L., Computer Organization and Design: The Hardware/Software Interface, 5<sup>th</sup> ed., Morgan Kaufmann, Amsterdam, 2014.
2. Stallings, W., Computer Organization and Architecture: Designing for Performance, 9<sup>th</sup> ed., Pearson Education, Boston, 2013.
3. Tanenbaum, A.S. and Austin, T., Structured Computer Organization, 6<sup>th</sup> ed., Pearson Education, 2013.

### CSL203 CONCEPTS IN PROGRAMMING LANGUAGES (3-0-2-8)

#### Contents:

Definition of Programming language. Syntax, semantics. High-level languages. Implementation of high-level languages, Compilers and Software interpreters. Data elements, identifiers binding, binding time, binding identifiers to names, binding of attributes, importance of binding time. Concept of r-value and l-value. Effect of environment on a language. Language paradigms.

Data type, elementary data type, structured data type, elements of specification and implementation of data type. Implementation of elementary data types: integer, real, character, Boolean and pointer. Implementation of structured data types. Vectors & arrays, records and files. Type checking, type conversion and initialization.

Evolution of data type concept. Abstract data type, encapsulation. Design and implementation of new data types through subprograms. Subprogram definition and activation, their implementation, parameter passing, generic subprograms. Sequence control structures used in expressions and their implementation. Sequence control structures used between statements or group of statements and their implementation. Sequence control structures used between subprograms, recursive and non-recursive subprogram calls. Data control, referring environment dynamic and static scope, static chain implementation and display implementation.

Type definition as mechanism to create new abstract data types, type equivalence, type definitions with parameters. Defining new abstracts data types. Storage management issues, like static and dynamic allocation, stack based allocation and management, Heap based allocation and management. Garbage collection. Introduction to exception handling.

### **Text Book:**

1. Pratt, T.W., Zelkowitz, M.V. and Gopal, T.V., Programming Languages Design and Implementation, 4<sup>th</sup> ed., Pearson Education, 2006

### **Reference Book:**

1. Sethi R., Programming Languages: Concepts and Constructs, 2<sup>nd</sup> ed., Pearson Education, Delhi, India, 2005.

## **CSL204 INTRODUCTION TO OBJECT ORIENTED METHODOLOGY (3-0-2-8)**

### **Contents:**

Object Oriented Programming, Features of object oriented programming languages like data encapsulation, inheritance, polymorphism and late binding. Concept of a class, Access control of members of a class, instantiating a class, static and non-static members, overloading a method.

Deriving a class from another class, access control of members under derivation, different ways of class derivation, overriding of a method, run time polymorphism.

Concept of an abstract class. Concept of an interface. Implementation of an interface.

Exception and exception handling mechanisms. Study of exception handling mechanisms in object-oriented languages

Introduction to streams, use of stream classes. Serialization and de-serialization of objects.

Templates, Implementation of data structures like linked lists, stacks, queues, trees, graphs, hash table etc. using object oriented programming languages.

Introduction to concept of refactoring, modeling techniques like UML, Design patterns.

### **Text Books:**

1. Arnold K., Gosling J. and Holmes, D., The Java Programming Language, 3<sup>rd</sup> ed., Pearson Education, 2013.
2. Weisfeld, M.A., The Object-Oriented Thought Process, 3<sup>rd</sup> ed., Pearson, 2013.

### **Reference Books:**

1. Stroustrup, B., The C++ Programming Language, 4<sup>th</sup> ed., Addison-Wesley, 2014
2. Schildt, H., C++: The Complete Reference, 5<sup>th</sup> ed., McGraw-Hill, 2012.
3. Cox, B.J. and Novobilski, A.J., Object-Oriented Programming: An Evolutionary Approach, 2<sup>nd</sup> ed., Addison Wesley, 1993.

## **CSL301 THEORY OF COMPUTATION (3-2-0-8)**

Pre-requisite: CSL 201 Data Structures and Program Design SCL 401 Discrete Mathematics

### **Contents:**

Preliminaries - Sets, operations, relations, transitive closure, countability and diagonalisation, induction and proof methods- pigeon-hole principle and simple applications- concept of language- grammars and production rules- Chomsky hierarchy. Regular grammars, deterministic finite automata - non determinism, conversion to deterministic automata-e-closures, regular expressions, finite automata, regular sets. Pump lemma for regular sets- closure properties of regular sets, decision properties for regular sets, minimization of automata. Context-free languages, parse trees and ambiguity, reduction of CFGs, Chomsky and Griebach normal forms, push-down Automata (PDA), non-determinism, acceptance by two methods and their equivalence, CFLs and PDAs - Pumping lemma for context free languages, Closure and decision properties of CFLs. Timing machines- variants, recursively enumerable (r. e.) sets, recursive sets, TM as computer of function, decidability and solvability, Halting Problem, reductions, Post correspondence Problem (PCP) and insolvability of ambiguity problem of CFGs.

Introduction to recursive function theory - primitive recursive and partial recursive functions Church-Turing thesis- convergence of viewpoints of what "computability" is: Semi formal treatment.

### **Text Book:**

1. Martin, J.C., Introduction to Languages and the Theory of Computation, 3<sup>rd</sup> ed., Tata McGraw Hill, 2014.

### **Reference Book:**

1. Hopcroft, J.E., Motwani, R. and Ullman, J.D., Introduction to Automata Theory, Languages and Computation, 3<sup>rd</sup> ed., Pearson Education, 2014.

## **CSL302 OPERATING SYSTEMS (3-0-2-8)**

Pre-requisites: CSL 201 Data Structures and Program Design CSL 202 Computer Organization

### **Contents:**

Introduction, basic h/w support necessary for modern operating systems - Services provided by OS, system programs and system calls - brief discussions of evolution of OS- real time and distributed systems: a brief overview of issues. File systems, user interface - disk space management and space allocation strategies- examples from UNIX, DOS, Windows etc- directory structures- disk cach

ing- file system consistency and logs- disk arm scheduling strategies. Processes and 3 levels of scheduling - process control block and context switch - goals of scheduling and different scheduling algorithms- threads: user-level and kernel level. Memory management techniques - contiguous and non-contiguous- paging and segmentation - translation look-aside buffers (TLB) and overheads - virtual memory and demand paging- page faults and instruction restart - problems of large address spaces - page replacement algorithms and working sets - miscellaneous issues. Process cooperation and synchronization - mutual exclusion and implementation - semaphores, conditional critical regions and monitors - classical inter-process communication problems- message passing. Deadlocks and strategies for handling them. Protection and security issues - access lists, capabilities, cryptographic techniques - introduction to distributed systems.

### **Text Books:**

1. Silberschatz, A., Galvin, P.B. and Gagne, G., Operating System Concepts, 8<sup>th</sup> ed., Wiley, 2014.
2. Stallings, W., Operating Systems: Internals and Design Principles, 7<sup>th</sup> ed., Pearson, 2014.

### **Reference Books:**

1. Crowley, C., Operating Systems: A Design-Oriented Approach, Tata McGraw Hill, 2001.
2. Tanenbaum, A.S., Modern Operating Systems, 3<sup>rd</sup> ed., Prentice Hall of India, 2014.

## **CSL303 COMPUTER NETWORKS (3-0-2-8)**

Pre-requisite: CSL308 Analysis of Algorithms

### **Contents:**

Introduction to Network Architecture, Layering and Protocols, Internet Architecture Implementing Network Software, Application Programming Interface (Sockets), Protocol Implementation Issues, Performance, Bandwidth and Latency, Delay  $\times$  Bandwidth Product, High-Speed Networks, Application Performance Needs Perspectives on Connecting Classes of Links, Encoding (NRZ, NRZI, Manchester, 4B/5B), Framing, Byte-Oriented Protocols (PPP), Bit-Oriented Protocols (HDLC), Clock-Based Framing (SONET), Error Detection, Two-Dimensional Parity, Internet Checksum Algorithm, Cyclic Redundancy Check, Reliable Transmission, Stop-and-Wait, Sliding Window, Concurrent Logical Channels, Ethernet and Multiple Access Networks (802.3), Physical Properties, Access Protocol. Introduction to Wireless technologies, 802.11/Wi-Fi, Bluetooth/802.15.1, Cell Phone Technologies, Security of Wireless Links, Internetworking, Switching and Bridging, Datagrams, Virtual Circuit Switching, Source Routing, Bridges and LAN Switches, Basic Internetworking (IP), Service Model, Global Addresses, Datagram Forwarding in IP, Subnetting and Classless Addressing, Address Translation (ARP), Host Configuration (DHCP), Error Reporting (ICMP), Virtual Networks and Tunnels, Routing, Network as a Graph, Distance Vector (RIP), Link State (OSPF), Metrics, Implementation and Performance, Ports, Fabrics, Router Implementation Advanced Internetworking -The Global Internet, Routing Areas, Inter domain Routing (BGP), IP version 6 (IPv6), Multicast, Multicast Addresses, Multicast Routing (DVMRP, PIM, MSDP), Multiprotocol Label Switching (MPLS), Destination-Based Forwarding, Explicit Routing, Virtual Private Networks and Tunnels, Routing among mobile devices, Challenges for Mobile Networking, Routing to Mobile Hosts (Mobile IP) End-to-End Protocols- Simple Demultiplexer (UDP), Reliable Byte Stream (TCP), End-to-End Issues, Segment Format, Connection Establishment and Termination, Sliding Window Revisited, Triggering Transmission, Adaptive Retransmission, Record Boundaries, TCP Extensions, Alternative Design Choices, Remote Procedure Call, RPC Fundamentals, RPC Implementations (SunRPC, DCE), Transport for Real-Time Applications (RTP) - Requirements, RTP Design, Control Protocol Congestion Control and Resource Allocation, Issues in Resource Allocation, Network Model, Taxonomy, Evaluation Criteria, Queuing Disciplines, FIFO, Fair Queuing, TCP Congestion Control, End-to-End Data-Presentation Formatting, Taxonomy, Examples (XDR, ASN.1, NDR), Markup Languages (XML), Multimedia Data, Lossless Compression Techniques, Image Representation and Compression (GIF, JPEG), Video Compression (MPEG), Transmitting MPEG over a Network, Audio Compression (MP3) Applications- Traditional Applications - Electronic Mail (SMTP, MIME, IMAP), World Wide Web (HTTP), Web Services Multimedia Applications - Session Control and Call Control (SDP, SIP, H.323), Resource Allocation for Multimedia Applications, Common Services, Name Service (DNS), Network Management (SNMP), Overlay Networks - Routing Overlays, Peer-to-Peer Networks, Content Distribution Networks.

### **CN Lab:**

Programs based on

1. Using TCP sockets or Network socket programming
2. Client-server application for chat
3. PC to PC file transfer using serial port
4. Implementation of Shortest path routing
5. Implementation of Sliding Window Protocol
6. Implementation of Address Resolution Protocol



## CSL308: ANALYSIS OF ALGORITHMS

### (3-2-0-8)

Pre-requisite: CSL 201 Data Structures and Program Design

#### Contents:

Mathematical foundations, summation of arithmetic and geometric series,  $\sum_n$ ,  $\sum_{n2}$ , Bounding summations using integration, recurrence relations, solutions of recurrence relations using technique of characteristic equation and generating functions.

Asymptotic notations of analysis of algorithms, analyzing control structures, worst case and average case analysis, amortized analysis, sorting algorithms such as selection sort, insertion sort, bubble sort, heap sort, lower bound proof, elementary and advanced data structures with operations on them and their time complexity.

Divide and conquer basic strategy, binary search, quick sort, merge sort, Fast Fourier Transform etc. Greedy method - basic strategy, application to job sequencing with deadlines problem, minimum cost spanning trees, single source shortest path etc.

Dynamic Programming basic strategy, multistage graphs, all pairs shortest path, single source shortest paths, optimal binary search trees, traveling salesman problem.

Basic Traversal and Search Techniques, breadth first search and depth first search, connected components. Backtracking basic strategy, 8-Queen's problem, graph coloring, Hamiltonian cycles etc. NP-hard and NP-complete problems, basic concepts, nondeterministic algorithms, NP-hard and NP-complete, Cook's Theorem, decision and optimization problems, polynomial reduction.

#### Text Books:

1. Cormen, T.H., Leiserson, C.E. and Rivest, R.L., Shamir, Introduction to Algorithms, 3<sup>rd</sup> ed., PHI Learning Private Ltd., 2013.
2. Horowitz, E., Sahni, S. and Rajasekaran, S., Fundamentals of Computer Algorithms, 2<sup>nd</sup> ed., University Press, 2012.

#### Reference Book:

1. Brassard, G. and Bratley, P., Fundamentals of Algorithmics, PHI Learning Private Limited, 2008.

## CSL309 NEURO-FUZZY TECHNIQUES

### (3-0-2-8)

#### Contents:

Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms- Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms- perceptions, Training rules, Delta, Back Propagation Algorithm, Multi-layer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.

Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations.

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. Application of Fuzzy Logic: Medicine, Economics etc.

Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks. Genetic Algorithm: An Overview of GA, GA operators, GA in problem solving, Implementation of GA.

#### Text Books:

1. Haykin, S.S., Neural Networks and Learning Machines, 3<sup>rd</sup> ed., PHI Learning, 2013.
2. Ross, T.J., Fuzzy Logic with Engineering Applications, 3<sup>rd</sup> ed., John Wiley & Sons, 2013.

#### Reference Books:

1. Aliev, R.A. and Aliev, R.R., Soft Computing and its Applications, World Scientific, 2001.
2. Kosko, B., Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, Prentice-Hall of India, 1994.
3. Yegnanarayana, B., Artificial Neural Networks, Prentice Hall of India, 2006.
4. Jang, J-S.R., Sun, C-T. and Mizutani, E., Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, PHI Learning, 2010.
5. Hertz, J.A., Krogh, A. and Palmer, R.G., Introduction to the Theory of Neural Computation, Addison Wesley, 1999.
6. Mehrotra, K., Mohan, C. K. and Ranka, S., Elements of Artificial Neural Networks, Penram International Publishing, 1997.

## CSL310 COMPUTER GRAPHICS (3-0-2-8)

Pre-requisite: CSL 201 Data Structures and Program Design

#### Contents:

Basic fundamentals of random scan, raster-scan devices, LCD displays - point and line drawing techniques and algorithms - input/output devices and interactive techniques.

Polygon filling methods: Seed fill, edge flag algorithm etc. - scan conversion techniques - anti aliasing techniques - clipping algorithms, Polygon clipping, Viewing transformation, Windowing transformation.

Linear transformation: rotation, scaling, translation in 3D - homogeneous coordinates - normalized device coordinates - windowing and view porting, Cartesian Coordinates, Word view etc.

Curve generation - cubic splines, Beziers, blending of curves- other interpolation techniques, Displaying Curves and Surfaces, Shape description requirement, parametric function.

Review of 3D vector algebra - parallel and perspective projections and transformation - hidden line/ surface elimination - shading and rendering - ray tracing techniques.

Graphics software packages - segmentation and display files - graphics standards - graphics and computer networks - basic principles of X windows, X terminals, Functions for segmenting display files.

#### Text Book:

1. Rogers, D.F., Procedural Elements for Computer Graphics, 2<sup>nd</sup> ed., Tata McGraw Hill, 2012.

#### Reference Books:

1. Hearn, D. and Baker, M.P., Computer Graphics, Prentice Hall of India, 2003.
2. Foley, J.D., Introduction to Computer Graphics, Addison-Wesley, 2010.

## CSL311 INTERNET TECHNOLOGIES

### (3-0-2-8)

#### Contents:

Evolution of Internet, TCP/IP: addressing and routing. Internet applications: FTP, Telnet, Email, Chat. World Wide Web: HTTP protocol. Designing web pages: HTML, forms, CGI scripts and clickable maps, JAVA applets, JavaScript, JAVA servlets, Perl. DHTML, XML.

E-Commerce and security issues including symmetric and asymmetric key, encryption and digital signature, authentication. Emerging trends, Internet telephony, virtual reality over the web, etc. Intranet and Extranet, firewall design issues.

#### Text Book:

1. Comer, D. Internetworking with TCP/IP: Principles, Protocols and Architecture, Vol. I, 6<sup>th</sup> ed., Pearson Education, 2014.

#### Reference Books:

1. Fall, K.R. and Stevens, W. R., TCP/IP Illustrated: The Protocols, Vol. I, 2<sup>nd</sup> ed., Addison Wesley, 2012.
2. Stevens, W. R. and Wright, G.R., TCP/IP Illustrated: The Implementation, Vol. II, Addison Wesley, 2010.
3. Stevens, W. R., TCP/IP Illustrated: TCP for Transactions, HTTP, NNTP, and the UNIX Domain Protocols, Vol. III, Addison Wesley, 2011.
4. Comer, D. and Stevens, D.L., Internetworking with TCP/IP: Client Server Programming and Applications, Vol. III, Prentice Hall of India, 2007.

## CSL312 TOPICS IN GRAPH THEORY (3-2-0-8)

Pre-requisites: SCL401 Discrete Mathematics  
CSL308 Analysis of Algorithms

#### Contents:

Introduction to Graphs, Bipartite graphs, Regular graphs, Complete graphs, Independent set, Cut-Vertices/Cut-Edges, Trees, Operation on graphs.

Matchings and covers, Matchings in Bipartite Graphs, Maximum Matchings, Hall's Matching Condition, Independent Sets, Applications and Algorithms, Dominating Sets, Bipartite Matchings, Matchings in General Graphs, Tutte's 1-factor Theorem,  $f$ -factors of Graphs, Cuts and connectivity, Edge-connectivity,  $K$ -connected and  $K$ -edge connected graphs, 2-connected Graphs, Applications of Menger's Theorem, Network flow problems, Maximum Network Flow, Integral Flows. Colorings of graphs, Vertex Colorings and Upper Bounds, Upper Bounds, Brooks' Theorem, Structuring of  $K$ -chromatic graphs, Critical Graphs, Enumerative Aspects, chordal graphs, Line Graphs and Edge-coloring, Hamiltonian Cycles, The Chinese Postman Problem, Heuristics and Bounds. Planer graphs, Embedding, Euler's formula, Dual Graphs, Characterization of Planar Graphs, Preparation for Kuratowski's Theorem, Parameters of planarity, Coloring of Planar Graphs, Edge-colorings and Hamiltonian Cycles.

Advanced topics: Perfect Graphs, the Perfect Graph Theorem, Imperfect Graphs, the Strong Perfect Graph Conjecture. Matroids, Hereditary Systems and Examples, The Span Function and Duality, Ramsey Theory, Ramsey's Theorem, Graph Ramsey Theory, More Extremal Problems, Branching and Gossip, Partitions Using Paths and Cycles, Random Graphs, Connectivity, Cliques, and Coloring, Eigenvalues of Graphs, Graph Pebbling. Electrical Network Analysis and Operations Research, Applications in Switching and Coding Theory.

#### **Text Book:**

1. Deo, N., Graph Theory: With Applications to Engineering and Computer Science, Prentice Hall of India, 2013.

#### **Reference Books:**

1. Harary, F., Graph Theory, Perseus Books, 2001.
2. West, D.B., Introduction to Graph Theory, 2<sup>nd</sup> ed., PHI Learning Pvt. Ltd., 2011.

### **CSL401 REAL-TIME SYSTEMS (3-0-2-8)**

Pre-requisite: CSL302 Operating Systems

#### **Contents:**

Real time applications: Hard and soft real time systems, timing constraints, A Reference model of Real-time systems, temporal parameters, precedence constraints & dependencies, scheduling Hierarchy, Commonly used approaches to scheduling, cyclic and priority drive approaches, Optimality of EDF and LST. Clock Driven Scheduling: Static timer driven scheduler, Cyclic Executives, Improving Average Response times of Aperiodic Jobs, Scheduling Sporadic jobs, Practical Considerations, Pros and Cons of Clock Driven Scheduling Priority-driven scheduling of periodic tasks: Fixed Priority vs Dynamic Priority schemes, Maximum schedulable Utilization, Optimality of the RM and DM algorithms, As Schedulable Test for Fixed Priority Tasks, Practical Factors. Scheduling Aperiodic and Sporadic Jobs in Priority-driven scheduling: Deferrable Servers, Sporadic Servers, Constant Utilization, Total Bandwidth, and Weighted Fair-Queueing Servers, Scheduling of Sporadic Jobs. Resources and resource access control: non preemptive critical sections, basic priority-inheritance, ceiling protocol, multiprocessor scheduling, predictability and validation of dynamic multiprocessor systems flexible applications, tasks with temporal distance constraints. Real time Operating systems: Overview, Time Services and Scheduling Mechanisms, Basic Operating System Functions, Processor Reserves and Resource Kernel, Open System Architecture, Capabilities of Commercial RTOS.

#### **Text Book:**

1. Liu, J.W.S., Real-Time Systems, Pearson Education, 2013.

#### **Reference Book:**

1. Krishna, C.M. and Shin, K.G., Real Time Systems, 3<sup>rd</sup> ed., Tata McGraw Hill, 2010.

### **CSL402 ARTIFICIAL INTELLIGENCE (3-0-2-8)**

Pre-requisite: CSL308 Analysis of Algorithms

#### **Contents:**

Introduction: What is AI?, History, Overview, Intelligent Agents, Performance Measure, Rationality, Structure of Agents, Problem-solving agents, Problem Formulation, Uninformed Search Strategies. Informed (Heuristic) Search and Exploration, Greedy best first search, A\* search, Memory bounded heuristic search, Heuristic functions, inventing admissible heuristic functions, Local Search algorithms, Hill-climbing, Simulated Annealing, Genetic Algorithms, Online search. Constraint Satisfaction Problems, Backtracking Search, variable and value ordering, constraint propagation, intelligent backtracking, local search for CSPs, Adversarial Search, Games, The minimax algorithm, Alpha-Beta pruning, Imperfect Real-Time Decisions, Games that include an Element of Chance. Knowledge Based Agents, Logic, Propositional Logic, Inference, Equivalence, Validity and Satisfiability, Resolution, Forward and Backward Chaining, DPLL algorithm, Local search algorithms, First Order Logic, Models for first order logic, Symbols and Interpretations, Terms, Atomic sentences, complex sentences, Quantifiers, Inference in FOL, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution. Planning, Language of planning problems, planning with state-space search, forward and backward state-space search, Heuristics for state-space search, partial order planning, planning graphs, planning with propositional logic. Uncertainty, Handling uncertain knowledge, rational decisions, basics of probability, axioms of probability, inference using full joint distributions, independence, Baye's Rule and conditional independence, Bayesian networks, Semantics of Bayesian networks, Exact and Approximate inference in Bayesian Networks.

#### **Text Book:**

1. Russell, S.J. and Norvig, P., Artificial Intelligence: A Modern Approach, 3<sup>rd</sup> ed., Pearson Education, 2014.

#### **Reference Books:**

1. Nilsson, N.J. Artificial Intelligence and New Systems, 1<sup>st</sup> ed., Elsevier, 2011.
2. Patterson, D.W., Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India, 2012.

### **CSL403 FUNDAMENTAL ALGORITHMS IN COMPUTATIONAL BIOLOGY (3-0-2-8)**

Pre-requisite: SCL 404: Probability and Numerical Methods  
CSL 308: Analysis of Algorithms

#### **Contents:**

DNA and Sequence Alignment – KMP-algorithm, BLAST and FASTA, Sorting by Reversals, Biological Databases – formats, downloading and using data, Phylogeny – Distance based algorithms (Hamming /Euclidian distance), Suffix Trees, Prediction of RNA secondary structure, Gene Prediction using Bayesian Methods and Markov Chains/HMMs, Modeling-Based on Cellular Automata, Based on Agent Based Modeling Techniques, Based on Partial Differential Equations, Single Nucleotide Polymorphism and algorithms for their identification, Microarray Data and Clustering – Hierarchical/K-Means, Pathway Data and their analysis, Protein Folding and Docking based on Entropy calculation

#### **Text Books:**

1. Ellner, S. P. and Guckenheimer, J., Dynamic Models in Biology, New Age International, 2010.
2. Murray, J. D., Mathematical Biology: An Introduction, 3<sup>rd</sup> ed., Springer, 2002.

#### **Reference Books:**

1. Mandouli, I. and Zelikovsky, A., Bioinformatics Algorithms: Techniques and Applications. Wiley Series on Bioinformatics: Computational Techniques and Engineering, John Wiley & Sons, 2008.
2. Course Website of Ron Shamir, Tel Aviv University (<http://www.cs.tau.ac.il/~rshamir/algmb/algmb-archive.htm>).

### **CSL404 NETWORK SECURITY (3-0-2-8)**

Pre-requisites: CSL 303 Computer Networks  
CSL 302 Operating Systems  
SCL 401 Discrete Mathematics

#### **Contents:**

Classical Ciphers: Affine, Playfair, Hill Cipher, Modern Block and Stream Ciphers: DES, AES, RC4, A5/1, Block Modes of Operation: ECB, CBC, CFB, OFB, CTR Asymmetric Key Cryptosystems: RSA, Digital Signatures: DSS, Hash and MAC: SHA-512 Key Management: Digital Certificates, PKI, Authentication: One-Way Authentication, Mutual Authentication, Dictionary Attacks, Centralized Authentication, The Needham-Schroeder Protocol, Kerberos, Network Layer Security: IPsec, Transport Layer Security: SSL/TLS Non-cryptographic Protocol Vulnerabilities: DoS and DDos, Session Hijacking and Spoofing, ARP Spoofing and Attacks on DNS, Software Vulnerabilities: Phishing, Buffer overflow, cross site scripting and SQL injection Viruses, Worms, and other Malware: Virus and Worm Features, Internet Scanning Worms, Mobile Malware and Botnets, Access Control in Operating Systems: Discretionary Access Control, Mandatory Access Control, Role Based Access Control, SELinux and Recent Trends, RFIDs and E-Passports Electronic payment

#### **Text Books:**

1. Forouzan, B.A. and Mukhopadhyay, Debdeep, Cryptography and Network Security, 2<sup>nd</sup> ed., Tata McGraw Hill, 2013.
2. Stallings, W., Cryptography and Network Security: Principles and Practice, 6<sup>th</sup> ed., Pearson, 2014.

#### **Reference Books:**

1. Schneier, B., Applied Cryptography: Protocols, Algorithms and Source Code in C, 2<sup>nd</sup> ed., Wiley-India, 2007.
2. Stinson, D.R., Cryptography: Theory and Practice, 3<sup>rd</sup> ed., Chapman and Hall CRC Press, 2006.
3. Menezes, A.J., Oorschot, P.C.V. and Vanstone, S.A., Handbook of Applied Cryptography, 5<sup>th</sup> ed., CRC Press, 2001.
4. Kaufman, C., Perlman, R. and Speciner, M., Network Security: Private Communication in a Public World, 2<sup>nd</sup> ed., Prentice Hall, 2010.
5. Pfleeger, C.P. and Pfleeger, S.L., Security in Computing, 4<sup>th</sup> ed., Prentice Hall, 2012.
6. Menezes, B., Network Security and Cryptography, Cengage Learning, 2012.

### **CSL405 DATA MINING AND DATA WAREHOUSING (3-0-2-8)**

Pre-requisite: CSL305 Database Management Systems

#### **Contents:**

Introduction to Data Warehousing- Application of Data Warehousing and mining, Datawarehouse development life cycle, Data warehouse analysis, CUBE, ROLL UP and STAR queries.

Data warehouse Architecture, OLAP, ROLAP and MOLAP, Concepts of Fact and Dimension table.

Space Management in Datawarehouse- Schemas for storing data in warehouse using different storage structures, B-tree index, hash index, clusters, Bitmap index functional index, domain index, Data partitions.

Performance and Tuning- Query optimization, memory management, process management.I/o management for Data warehouse.

Data Mining Tools –Association rules, a priori algorithm, Fp-trees algorithm, constraints and solution.

Cluster analysis- paradigms, DBSCAN, cluster algorithms.

Mining tools- decision trees and applications.

#### **Text Books:**

1. Han, J., Kamber, M. and Pei, J., Data Mining: Concepts and Techniques, 3<sup>rd</sup>ed., Elsevier, 2013.

2. Corey, M.J. and et. al., Oracle 8i Data Warehousing, McGraw Hill, 2001.

#### **Reference Books:**

1. Elmasri, R.A. and Navathe, S.B., Fundamentals of Database Systems, 6<sup>th</sup>ed., Pearson, 2014.

2. Pujari, A.K., Data Mining Techniques, 3<sup>rd</sup> ed., Hyderabad Universities Press Pvt. Ltd., 2013.

## **CSL406 ADVANCED COMPUTER**

### **ARCHITECTURE (3-0-2-8)**

Pre-requisites: CSL202 Computer Organization

#### **Contents:**

Classes of computers, Trends in technology, power and costs, dependability, quantitative principles of computer design, Amdahl's Law, Introduction to computing models. Pipeline and superscalar techniques, linear pipeline processors, reservation and latency analysis, collision free scheduling, pipeline schedule optimization, instruction pipeline design, arithmetic pipeline design, super scalar and super pipeline design. Principles of scalable performance, performance metrics and measures, speedup performance laws, advanced processor technology, superscalar and VLIW processors. Elementary theory about dependence analysis, techniques for extraction of parallelism, branch prediction, dynamic scheduling, multiple issue and speculation, limits on instruction level parallelism. Memory hierarchy, cache performance, protection and examples of virtual memory. Cache Optimizations. Multiprocessors and multi-computers, Brief overview of SIMD, MIMD, vector architectures and multi-core architectures. Verified memory, cache memory organizations, shared memory organizations. Cache coherence. Thread level parallelism.

#### **Text Book:**

1. Hennessy, J.L., Patterson, D.A. and Asanovic, K., Computer Architecture: A Quantitative Approach, 5<sup>th</sup> ed., Elsevier, 2013.

#### **Reference Books:**

1. Hwang, K., Ramachandran, A. and Purushothaman, R., Advanced Computer Architecture: Parallelism, Scalability, Programmability, Tata McGraw Hill, 2004.

2. Sima, D., Fountain, T.J. and Kacsuk, P. Advanced Computer Architectures: A Design Space Approach, Pearson Education, 2005.

## **CSL407 DISTRIBUTED SYSTEMS (3-0-2-8)**

Pre-requisite: CSL 302 Operating Systems

CSL 303 Computer Networks

#### **Contents:**

Motivation and goals, broad overview and advantages of distributed systems, main characteristics absence of global clock and state and possibility of large network delays

Issues in distributed systems such as transparency, scalability, security etc. Middlewares such as sockets, RPC, RMI etc. Distributed file systems- design issues- case studies with emphasis on NFS- distributed shared memory-coherence and coherence protocols- design issues and case studies, clock synchronization. Theoretical foundations- Lamport's clocks-Chandy-Lamport Global State recording algorithm- termination detection, leader election. Distributed mutual exclusion- Lamport, Ricart - Agrawal non-token based algorithm - token based algorithms- comparative performance analysis. Distributed deadlock detection issues- central and distributed detection algorithm- agreement protocols- model of processor failures- Byzantine agreement and other problems- solutions and applications. Distributed scheduling- issues, load distributing algorithms- load sharing policies and case studies- task migration and issues Recovery: introduction and basic concepts - backward and forward error recovery, Checkpointing: synchronous and asynchronous- atomic actions and commit protocols- voting protocols- reliable communication.

#### **Text Books:**

1. Singhal, M. and Shivaratri, N.G., Advanced Concepts in Operating Systems, Tata McGraw Hill, 2013.

2. Coulouris, G.F., Dollimore, J. and Kindberg, T., Distributed Systems: Concepts and Design, 4<sup>th</sup> ed., Pearson Education, 2012.

#### **Reference Book:**

1. Tanenbaum, A.S., Modern Operating Systems, 3<sup>rd</sup> ed., Prentice Hall, 2014.

## **CSL408 INFORMATION RETRIEVAL (3-0-2-8)**

#### **Contents:**

Boolean retrieval, the term vocabulary and postings lists, Dictionaries and tolerant retrieval, Introduction to index-construction and index-compression.

Scoring, term weighting and the vector space model, Computing scores in a complete search system, Evaluation in information retrieval, Introduction to Relevance feedback and query expansion.

Probabilistic information retrieval, review of basic probability theory, the probability ranking principle, the binary independence model

Language models for information retrieval, Language modeling versus other approaches to IR, Text classification and Naive Bayes, Bayesian Network approaches to IR. Vector space classification, Support vector machines and machine learning on documents, Flat clustering, Hierarchical clustering, Matrix decomposition and latent semantic indexing. Introduction to Web search basics, Web crawling and indexes, Link analysis.

#### **Text Books:**

1. Manning, C.D., Raghavan, P. and Schütze, H., Introduction to Information Retrieval, Cambridge University Press, England, 2012.

2. Bu'ttcher, S., Clarke, C.L.A. and Gordon V Cormack, Information Retrieval: Implementing and Evaluating Search Engines, MIT Press, 2010.

#### **Reference Books:**

1. Grossman, D.A. and Ophir, F., Information Retrieval: Algorithms and Heuristics, Springer, 2013.

2. Frakes, W.B., Pearson, Information Retrieval: Data Structures and Algorithms, Prentice Hall, 2002.

## **CSP401 SOFTWARE LAB (0-0-2-2)**

#### **Contents:**

Main theme- Use of open source tools.

Advanced use of Apache Web server: Installing and using Apache Web server in load sharing manner (Configuration of 2 or more server hosting a common website, Advanced use of MySQL server: Installing and using mysql servers in load sharing manner (Configuration of 2 MySQL instances in master-slave mode). Database operations via programs written in C/C++ or Java. Java Native Interface (JNI): Calling C/C++ code from Java and vice versa.

Automatic testing tools – Junit, NUnit, Advanced use of open source cloud platforms: Integration of gmail with google calendar – from gmail you should be able to schedule an appointment with all the recipients of the mail.

Creating a website on Salesforce cloud for tracking inventory from east, west, north, south regions in India separately. Accessing google-map via google-map APIs, Downloading and Installing Hadoop on 3 to 4 machines and writing a distributed sorting program on the same. Creating web-services using Axis-2 (Java) or gSoap library (C/C++) Introduction to SSL. Use digital certificates to encrypt/ decrypt data in transfers Notes- Keytool in Java allows to create/store/ manipulate certificates Also, refer www.thawte.com for free download/creation of a certificate Introduction to Android Platform and APIs/libraries provided. A sample game/application on Android. Learning software engineering tools, Design tools - Rational Rose/visio, Memory leaks - Purify /Code Coverage tools, Testing tools- Loadrunner, Winrunner.