



The New unified Syllabus for both CSe & IT are to be followed from the session 2013-14. Details of some electives are yet to be received for approval by BoS. The syllabus can only be offered after the details are approved by BoS & uploaded on the University website. No elective other than those listed & detailed are to be offered.

1. INTRODUCTION TO INTERNETWORKING: HOW NETWORKS DIFFER, HOW NETWORKS CAN BE CONNECTED, CONNECTIONLESS INTERNETWORKING, TUNNELING, FRAGMENTATION, OVERVIEW OF UNDERLYING TECHNOLOGIES (ETHERNET, TOKEN RING, TOKEN BUS, FDDI, PPP).  
[6 Lectures]
2. NETWORK LAYER PROTOCOLS: IPV4, IPV6, NAT, ARP, RARP, DHCP, ICMP, OSPF, BGP, IGMP, CIDR.  
[4 Lectures]
3. TRANSPORT LAYER PROTOCOLS: UDP, REMOTE PROCEDURE CALL, RTP, TCP, TCP TAHOE, TCP RENO, TCP NEW RENO, TCP SACK.  
[4 Lectures]
4. MOBILE TELEPHONE SYSTEMS: INTRODUCTION TO WIRELESS NETWORKS AND CELLULAR TECHNOLOGY, AMPS, D-AMPS, GSM, GPRS, CDMA, BLUETOOTH.  
[4 Lectures]
5. WIRELESS NETWORKS: WLAN: INTRODUCTION, PROBLEMS AND SOLUTIONS, PROTOCOL STACK, ACCESS METHODS, SERVICES, WIMAX, WIFI, ZIGBEE.  
[4 Lectures]
6. AD-HOC NETWORKS: INTRODUCTION, ROUTING CHALLENGES FOR AD-HOC NETWORKS, ROUTING PROTOCOLS (AODV, DSDV, DSR,), TRANSPORT PROTOCOLS (ATCP, TCP-F, TCP BUS).  
[4 Lectures]
7. WIRELESS INTERNET: MIPV4, MIPV6, TCP PERFORMANCE, I-TCP, TCP SNOOP, FREEZE TCP, WWP, TCP REAL.  
[4 Lectures]
8. CONGESTION CONTROL: GENERAL PRINCIPLES, CONGESTION PREVENTION POLICIES, CHOKE PACKET, RED, ECN, ELN, ELN-ACK.  
[4 Lectures]
9. QOS PROVISIONING: DELAY GUARANTEES, NETWORK DELAY, DELAY JITTER, PLAY OUT DELAY, ADMISSION CONTROL, QOS OBJECTIVES, THE RSVP APPROACH.  
[4 Lectures]
10. SECURITY: INTRODUCTION TO CRYPTOGRAPHY, SYMMETRIC KEY AND PUBLIC KEY ALGORITHMS, DIFFIE HELLMAN KEY EXCHANGE ALGORITHM, DIGITAL SIGNATURES, IPSEC, FIREWALL, VPN, VLAN, WIRELESS SECURITY, AUTHENTICATION PROTOCOLS.  
[6 Lectures]

#### BOOKS

1. INTERNETWORKING WITH TCP/IP: PRINCIPLES, PROTOCOLS, AND ARCHITECTURE - DOUGLAS COMER.
2. COMPUTER NETWORKS -A.S.TANNENBAUM.
3. DATA AND COMPUTER COMMUNICATIONS - WILLIAM STALLINGS
4. WIMAX SECURITY & QOS-AN END-TO-END PERSPECTIVE: ISBN: 978-0-470-72197-1, WILEY PUBLICATION.

**PGCSE203: Theory of Computation [ Compulsory] Mathematical preliminaries.**

#### Models of Computation

: Models of computation - classification, properties and equivalences.

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### **Finite Automata**

: Formal definition of a Finite Automata (FA) -Examples of FA, Designing FA, DFA and NFA, regular operations. Equivalence of NFAs and DFAs. FA with Epsilon-Transitions, Epsilon-Closures, Eliminating epsilon -Transitions. Applications of FAs. Mealy and Moore machine, Dead state, Minimization of FA, Incompletely specified machine. FA on infinite inputs.

### **Regular expression and Languages**

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

### **Context Free Languages**

: Context free languages, Derivation and languages, Relationship between derivation and derivation trees, Leftmost and Rightmost Derivations. Simplification of context free grammars – Normal forms for context free grammars, CNF, and GNF.

Applications of Context-Free Grammars. Non determinism vs. ambiguity in CFLs. Closure properties of CFLs. Algorithmic

properties about CFLs. Pumping Lemma for CFL.

### **Push Down Automata**

: Definition, Acceptance by a Push Down Automata (PDA), DPDA & NPDA, example, Equivalence of PDA's and CFG's

(conversion : PDA's to CFG's and reverse). Multi stack PDA. Non-determinism adds power to PDAs.

### **Turing Machine**

: Unsolvable Problems. Definition, notation and Example of Turing Machine (TM). Programming techniques Computable

languages and functions, Church Turing hypothesis, Universal TM, Random Access TM. Multitape TM, Equivalence of

One-Tape and Multitape TM's , Nondeterministic TMs. Conversion of RE to TM. Multi-stack PDA & TM.

**Computability and Decidability:** Church-Turing Thesis, Decision Problems, Decidability and undecidability, unsolvable problems; Halting Problem of

Turing Machines; Problem reduction (Turing and mapping reduction), Intractability (Hierarchy Theorems). Mapping reductions. More undecidable languages. Rice theorem. Reductions using controlled executions. RE Completeness.

Reductions using computation histories. Linear Bounded Automata. Unrestricted grammars.

### **Computational Complexity:**

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

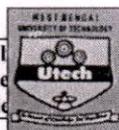
**Logic:** Propositional and First-order logic and their applications to theorem proving and logic programming.

**Advanced/Emerging areas:** Elementary introductions to DNA Computing, Quantum Computing, Cellular Automata, Circuit complexity, Structural Complexity, Parallel Complexity, Algorithmic Information.

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Course Guidelines: Large majority of the lectures would focus only on the core areas, with only elementary introduction to other remaining advanced areas.

## Elective – II

### Cluster, Grid and Cloud Computing

**Code: PGCSE204A**

**Contact: 4L**

**Credit: 4**

**Allotted Hrs: 44**

#### Cluster Computing [12L]

A general introduction to the concept of cluster based distributed computing.

Hardware technologies for cluster computing, including a survey of the possible node hardware and high-speed networking hardware and software.

Software and software architectures for cluster computing, including both shared memory (OpenMP) and message passing (MPI/PVM) models

MPI-2 extension, dynamic process creation, one-sided communication, parallel I/O.

Variants based on new low level protocols (MVAPICH), evaluation and tuning of system and software performance

Performance evaluation tools, HINT, netperf, netpipe, ttcp, Iperf.

#### Grid Computing [16L]

The Grid - Past, Present, Future, A New Infrastructure for 21st Century Science  
- The Evolution of the Grid - Grids and Grid Technologies, Programming models -  
A Look at a Grid Enabled Server and Parallelization Techniques – Grid applications

The concept of virtual organizations – Grid architecture – Grid architecture and relationship to other Distributed Technologies – computational and data Grids, semantic grids

Case Study: Molecular Modeling for Drug Design and Brain Activity Analysis,  
Resource management and scheduling, Setting up Grid, deployment of Grid software and tools, and application execution

#### Cloud Computing [16L]

Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS

Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing

Data in the cloud: Relational databases, Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo.

Issues in cloud computing, Implementing real time application over cloud platform

Issues in Intercloud environments, QoS Issues in Cloud, Dependability, data migration, streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment.

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#### Text Book:

- 1. Cluster Computing by Rajkumar Buyya, Clemens Szyperski
- 2. High Performance Cluster Computing: Architectures and systems by Rajkumar Buyya
- 3. Grid and Cluster Computing by C.S.R Prabhu
- 4. Fran Bernm, Geoffrey Fox, Anthony Hey J.G., "Grid Computing: Making the Global Infrastructure a Reality", Wiley, USA, 2003
- 5. Joshy Joseph, Craig Fallenstein, "Grid Computing", Pearson Education, New Delhi, 2004,
- 6. Ian Foster, Carl Kesselman, "The Grid2: Blueprint for a New Computing Infrastructure". Morgan Kaufman, New Delhi, 2004
- 7. Ahmar Abbas, "Grid Computing: Practical Guide to Technology and Applications", Delmar Thomson Learning, USA, 2004,
- 8. Cloud Computing for Dummies by Judith Hurwitz, R.Bloor, M.Kanfman, F.Halper (Wiley India Edition)
- 9. Enterprise Cloud Computing by Gautam Shroff, Cambridge
- 10. Cloud Security by Ronald Krutz and Russell Dean Vines, Wiley-India

#### PGCSE 204(B): Mobile Computing

(42 LECTURES)

#### Fundamentals of Cellular Communications [8L]

Introduction, First- and Second-Generation Cellular Systems, Cellular Communications from 1G to 3G, Teletraffic Engineering, Radio Propagation and Propagation Path-Loss Models, Cellular Geometry, Interference in Cellular Systems, Frequency Management and Channel Assignment Issues, Multiple Access Techniques, GSM Logical Channels and Frame Structure, Privacy and Security in GSM, Mobility Management in Cellular Networks.

#### Wireless Transmission Fundamentals [8L]

Spread Spectrum (SS) and CDMA Systems, Wireless Medium Access Control, IEEE 802.11 Architecture and Protocols, Issues in Ad

Hoc Wireless Networks (Medium Access Scheme), Routing, Multicasting, Transport Layer Protocols, QoS Provisioning, Energy Management and Energy Consumption Models, Traffic Integration in Personal, Local, and Geographical Wireless Networks, Bluetooth, Technologies for High-Speed WLANs, Third-Generation Cellular Systems: UMTS.

#### Mobile Adhoc Networks [8L]

Introductory Concepts. Different models of operation, Various applications of MANET, Destination-Sequenced Distance Vector protocol - overview, Route Advertisement, Extending Base Station Coverage, Properties of DSDV protocol, Dynamic Source Routing protocol - overview and properties, DSR Route Discovery, Route Maintenance, Support for Heterogeneous Networks and Mobile IP, Multicast routing with DSR, Ad Hoc On-Demand Distance-Vector protocol - properties, Unicast Route Establishment, Multicast Route Establishment, Broadcast Optimizations and Enhancements, Link Reversal Routing - Gafni-Bertsekas Algorithm, lightweight mobile routing algorithm, Temporally Ordered Routing Algorithm, Preserving battery life of mobile nodes - Associativity Based Routing, Effects of beaconing on battery life.

#### Wireless Sensor Networks [8L]

Sensor networks overview: introduction, applications, design issues, requirements, Sensor node architecture, Network architecture: optimization goals, evaluation metrics, network design principles, Sensor network operating systems and brief introduction to sensor network Programming, Network protocols: MAC protocols and energy efficiency, Routing protocols: data centric, hierarchical, location-based, energy efficient routing etc, Sensor deployment, scheduling and coverage issues, Self Configuration and Topology Control, Querying, data collection and processing, collaborative

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Overview, Computer Network, Intranet, Extranet and Internet. Types of Networks (LAN, MAN, WAN), Network Topologies. Definition of Internet, Internet organization. Growth of Internet, Internet Application.

#### Review of TCP/IP (2L):

OSI Reference model, TCP/IP Model, IP addressing, Classful and Classless Addressing, Subnetting, Features and services of TCP/IP, Three-Way Handshaking, Flow Control, Error Control, Congestion control, IP Datagram. Routing - Intra and Inter Domain Routing, Unicast and Multicast Routing, Broadcast. Electronic Mail-POP3, SMTP.

#### World Wide Web (2L):

Evolution of distributed computing. Core distributed computing technologies – Client/Server Architecture & its Characteristics, JAVA RMI.

Challenges in Distributed Computing, role of J2EE and XML in distributed computing, emergence of Web Services and Service Oriented Architecture (SOA). Introduction to Web Services – The definition of web services, basic operational model of web services, tools and technologies enabling web services, benefits and challenges of using web services.

Web Server Concept and Architecture. Definition of DNS (Domain Name System). Domain and Sub domain, Address Resolution, FTP & its usage, Telnet Concepts, Remote Logging, HTTP & HTTPs.

#### Module II-12L(Client Side Application Development)

##### HTML & CSS (3L):

Introduction, Editors, Elements, Tags, Attributes, Heading, Paragraph. Formatting, Link, Image, Table, List, Block, Form, Frame Layout, DHTML, Basic Web Page Development, CSS- Create Class Styles, Create ID Styles, Span, Colors. HTML5 in brief.

##### Extensible Markup Language (XML) (3L):

Brief Over View of XML – XML Document structure, XML namespaces, Defining structure in XML documents, Reuse of XML schemes, Document navigation and transformation, Tree, Syntax, Elements, Attributes, Validation, and Viewing. XHTML in brief.

##### JavaScript (6L):

Introduction, JavaScript in Web Pages, The Advantages of JavaScript Writing JavaScript into HTML; Building Up JavaScript Syntax; Basic

Programming Techniques ; Operators and Expressions in JavaScript; JavaScript Programming Constructs; Conditional Checking Functions in

JavaScript, Dialog Boxes, Statements, comments, variable, comparison, condition, switch, loop, break. Object – string, array. Function, Errors,

Validation. The JavaScript Document Object Model-Introduction (Instance, Hierarchy); The JavaScript Assisted Style Sheets DOM; Understanding

Objects in HTML (Properties of HTML objects, Methods of HTML objects); Browser Objects, Handling Events Using JavaScript

#### Module III-16L (Server Side Programming with PHP & MySQL)

##### Installing and Configuring (2L) :

Current and Future Versions of MySQL and PHP, How to Get MySQL, Installing MySQL on Windows, Trouble Shooting your Installation, Basic Security Guidelines, Building PHP on Windows with Apache, Windows, php.ini. Basics, The Basics of PHP scripts.

##### The Building blocks of PHP (3L):

Variables, Data Types, Operators and Expressions, Constants. Flow Control Functions in PHP: Switching Flow, Loops, Code Blocks and Browser

Output.

  
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**Code: PGCSE205A**

**Contact: 4L**

**Credit: 4**

**Allotted Hrs: 40**

**Introduction [5L]**

Background, Digital Image Representation, Fundamental steps in Image Processing, Elements of Digital Image Processing - Image Acquisition, Storage, Processing, Communication, Display.

**Digital Image Formation [6L]**

A Simple Image Model, Geometric Model- Basic Transformation (Translation, Scaling, Rotation), Perspective Projection, Sampling & Quantization - Uniform & Non uniform.

**Mathematical Preliminaries [7L]**

Neighbour 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.

**Image Enhancement [8L]**

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 pass filtering, High pass filtering.

**Image Restoration [7L]**

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.

**Image Segmentation [7L]**

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, Gonzalves, Pearson
2. Digital Image Processing, Jahne, Springer India
3. Digital Image Processing & Analysis, Chanda & Majumder, PHI
4. Fundamentals of Digital Image Processing, Jain, PHI
5. Image Processing, Analysis & Machine Vision, Sonka, VIKAS

### Elective - III

**Paper Name: Pattern Recognition**

**Paper Code: PGCSE205B**

**Contact: 4L**

**Credit: 4**

**Allotted Hrs: 38**

#### INTRODUCTION TO PATTERN RECOGNITION

Basic concepts- Definitions, data sets for Pattern Recognition, Structure of a typical pattern recognition system. Different Paradigms of Pattern Recognition. Representations of Patterns and Classes. Metric and non-metric proximity measures

#### FEATURES SELECTION

Feature vectors - Feature spaces - Different approaches to Feature Selection-Branch and Bound Schemes. Sequential Feature Selection.

#### FEATURES EXTRACTION

Principal Component Analysis (PCA), Kernel PCA

6

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**Advanced Computer Network Lab**

**CSEM294**

**Contact: 3L**

**Credit: 3**

**Allotted Lecture: 32P**

**Module-1**

4P

Programs using TCP Sockets (like date and time server & client, echo server & Client, etc..)

**Module-2**

4P

Programs using UDP Sockets (like simple DNS), Programs using Raw sockets (like packet capturing and filtering), Programs using RPC, Simulation of sliding window protocols

**Module-3**

6P

Experiments using simulators (like OPNET)

**Module-4**

6P

Performance comparison of MAC protocols

**Module-3**

12P

Performance comparison of Routing protocols

Study of TCP/UDP performance



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- Fermat Primality Test
- AKS PRIMALITY TEST

#### Factorization [5L]

- Large prime variant
- Dixon's factorization method
- Quadratic-Sieve Factoring
- Pollard-Rho Method

#### Eliptic curves Cryptography [3L]

- Elliptic Curves
- Elliptic Curves(contd.) and Finite Fields
- Elliptic Curve Cryptography
- ECDLP
- Zero Knowledge Proof

#### Bilinear Pairings (3L)

- Basic concept
- Identity based encryption
- Analogous of pairing based cryptosystems

#### Communication Security (4L)

- Secret Sharing Schemes
- A Tutorial on Network Protocols, Kerberos
- IPsec: AH and ESP
- IPsec: IKE
- SSL/TLS
- Intruders and Viruses
- Firewalls

#### Electronic Mail Security (4L)

- Distribution lists
- Establishing keys
- Privacy, source authentication, message integrity, nonrepudiation, proof of submission, proof of delivery, message flow confidentiality, anonymity • Pretty Good Privacy (PGP)
- S/MIME

#### Secure Electronic Transaction [4L]

- SET
- Millicent protocol
- Micropayment system
- Smart-card authentication **Text Books:**
  1. Public-key Cryptography: Theory and Practice by Abhijit Das and C E Veni Madhavan, First Edition, Publisher (Pearson Education)
  2. Cryptography and Network security: Principles and Practice by W. Stallings, Pearson Education
  3. Cryptography & Network Security, by B. A. Forouzan and D. Mukhopadhyay, Tata Mc Graw Hill
  4. Cryptography Theory and Practice, by Douglas Stinson, 2nd Edition, Chapman & Hall/CRC
  5. A Course in Number Theory and Cryptography by Neal Koblitz, Springer-Verlag, New York Inc
  6. Information theory, coding and cryptography by Ranjan Bose; TMH.
  7. Information and Coding by N Abramson; McGraw Hill.

Image Processing

Elective - III

  
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Data in the cloud: Relational databases, Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo. Issues in cloud computing, Implementing real time application over cloud platform  
Issues in Intercloud environments, QOS Issues in Cloud, Dependability, data migration, streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment.

**Text Book:**

1. Cluster Computing by Rajkumar Buyya, Clemens Szyperski
2. High Performance Cluster Computing: Architectures and systems by Rajkumar Buyya
3. Grid and Cluster Computing by C.S.R Prabhu
4. Fran Bernm, Geoffrey Fox, Anthony Hey J.G., "Grid Computing: Making the Global Infrastructure a Reality", Wiley, USA, 2003
5. Joshy Joseph, Craig Fallenstein, "Grid Computing", Pearson Education, New Delhi, 2004,
6. Ian Foster, Carl Kesselman, "The Grid2: Blueprint for a New Computing Infrastructure". Morgan Kaufman, New Delhi, 2004
7. Ahmar Abbas, "Grid Computing: Practical Guide to Technology and Applications", Delmar Thomson Learning, USA, 2004,
8. Cloud Computing for Dummies by Judith Hurwitz, R.Bloor, M.Kanfman, F.Halper (Wiley India Edition)
9. Enterprise Cloud Computing by Gautam Shroff, Cambridge
10. Cloud Security by Ronald Krutz and Russell Dean Vines, Wiley-India

**Advanced Operating System Lab**

**CSEM293**

**Contact:3L**

**Credit:3**

**Allotted Lecture:**

**Module-1**

**6P**

Preliminaries of Operating System:

Managing users, managing systems, file managements, useful commands.

**Module-2**

**9P**

Shell scripting

Shell syntax, executing shell scripts.

**Module-3**

**15P**

Process:

Creating new process, counting maximum number of processes a system can handle at a time, handling system calls; inter process communication through pipes and message passing, zombie process, orphan process.

**Module-4**

**6P**

Process Synchronization:

Handling threads and semaphores to achieve synchronization among processes using POSIX standard functions.

**Module-5**

**6P**

Signal: study of some POSIX signals (SIGINT, SIGILL, SIGFPE, SIGKILL, SIGHUP, SIGALRM, SIGABRT).

  
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4. D. F. Rogers, J. A. Adams – “Mathematical Elements for Computer Graphics (2nd Ed.)” – TMH
5. Mukherjee, Fundamentals of Computer graphics & Multimedia, PHI
6. Sanhker, Multimedia –A Practical Approach, Jaico
7. Buford J. K. – “Multimedia Systems” – Pearson Education
8. Andleigh & Thakrar, Multimedia, PHI
9. Mukherjee Arup, Introduction to Computer Graphics, Vikas
10. Hill, Computer Graphics using open GL, Pearson Education

**Reference Books:**

1. □Foley, Vandam, Feiner, Hughes – “Computer Graphics principles (2nd Ed.) – Pearson Education.
2. □W. M. Newman, R. F. Sproull – “Principles of Interactive computer Graphics” – TMH.
3. Elsom Cook – “Principles of Interactive Multimedia” – McGraw Hill

**Cluster, Grid and Cloud Computing**

**CSEM206F**

**Contact:3L**

**Credit:3**

**Allotted Lecture: 44**

**Module-1**

**Cluster Computing**

12L

A general introduction to the concept of cluster based distributed computing. Hardware technologies for cluster computing, including a survey of the possible node hardware and high-speed networking hardware and software. Software and software architectures for cluster computing, including both shared memory (OpenMP) and message passing (MPI/PVM) models

MPI-2 extension, dynamic process creation, one-sided communication, parallel I/O. Variants based on new low level protocols (MVAPICH), evaluation and tuning of system and software performance  
Performance evaluation tools, HINT, netperf, netpipe, ttcp, lperf.

**Module-2**

16L

**Grid Computing**

The Grid - Past, Present, Future, A New Infrastructure for 21st Century Science - The Evolution of the Grid - Grids and Grid Technologies, Programming models - A Look at a Grid Enabled Server and Parallelization Techniques – Grid applications. The concept of virtual organizations – Grid architecture – Grid architecture and relationship to other Distributed Technologies – computational and data Grids, semantic grids

Case Study: Molecular Modeling for Drug Design and Brain Activity Analysis, Resource management and scheduling, Setting up Grid, deployment of Grid software and tools, and application execution.

**Module-3**

**Cloud Computing**

16L

Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS

Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing

**Allotted Lecture: 40**

**Module-1**

Introduction to computer graphics & graphics systems

6L

Overview of computer graphics, representing pictures, preparing, presenting & interacting with pictures for presentations; Visualization & image processing; RGB color model, direct coding, lookup table; storage tube graphics display, Raster scan display, 3D viewing devices, Plotters, printers, digitizers, Light pens etc.; Active & Passive graphics devices; Computer graphics software.

**Module-2**

**Scan conversion:**

6L

Points & lines, Line drawing algorithms; DDA algorithm, Bresenham's line algorithm, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, fill algorithm, boundary fill algorithm, flood fill algorithm.

**Module-3**

2D transformation & viewing

6L

Basic transformations: translation, rotation, scaling; Matrix representations & homogeneous coordinates, transformations between coordinate systems; reflection shear; Transformation of points, lines, parallel lines, intersecting lines. Viewing pipeline, Window to viewport co-ordinate transformation, clipping operations, point clipping, line clipping, clipping circles, polygons & ellipse.

**Module-4**

**3D transformation & viewing**

6L

3D transformations: translation, rotation, scaling & other transformations. Rotation about an arbitrary axis in space, reflection through an arbitrary plane; general parallel projection transformation; clipping, viewport clipping, 3D viewing.

**Module-5**

Curves

3L

Curve representation, surfaces, designs, Bezier curves, B-spline curves, end conditions for periodic B-spline curves, rational B-spline curves.

**Module-6**

**Hidden surfaces**

3L

Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Painter's algorithm, scan-line algorithm; Hidden line elimination, wire frame methods, fractal - geometry.

**Module-7**

**Module-Color & shading models**

2L

Light & color model; interpolative shading model; Texture;

**Module-8**

Multimedia

8L

Introduction to Multimedia: Concepts, uses of multimedia, hypertext and hypermedia; Image, video and audio standards. Audio: digital audio, MIDI, processing sound, sampling, compression. Video: MPEG compression standards, compression through spatial and temporal redundancy, inter-frame and intra-frame compression. Animation: types, techniques, key frame animation, utility, morphing. Virtual Reality concepts.

**Text Books:**

2. Hearn, Baker – "Computer Graphics (C version 2nd Ed.)" – Pearson education
3. Z. Xiang, R. Plastock – "Schaum's outlines Computer Graphics (2nd Ed.)" – TMH

  
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### Recommended Book:

1. D. Jurafsky and J. H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition", Pearson Education, 2008.
2. J. Allen, "Natural Language Understanding", Addison Wesley, 2007.
3. J. Handke, "The Structure of the Lexicon: Human Versus Machine (Natural Language Processing)", Mouton de Gruyter, 1995.

### Mobile Computing

#### CSEM206D

Contact: 3L

Credit: 3

Allotted Lecture: 36

#### Module-1

8L

Introduction to Wireless Networks – Applications – History – Simplified Reference Model – Wireless transmission – Frequencies – Signals – Antennas – Signal propagation – Multiplexing – Modulation – Spread spectrum – Cellular Systems.

#### Module-2

8L

MAC – Motivation – SDMA, FDMA, TDMA, CDMA – Telecommunication Systems – GSM – DECT – TETRA – UMTS – IMT-2000.

#### Module-3

8L

Wireless LAN – Infrared Vs Radio transmission – Infrastructure – Adhoc Network – 802.11 – HIPERLAN – Bluetooth – Mobile Network Layer – Mobile IP – Dynamic Host Configuration Protocol.

#### Module-4

8L

Adhoc Networks – Mobile Transport Layer – Traditional TCP – Indirect TCP – Snooping TCP – Mobile TCP – Fast retransmit / Fast recovery – Transmission / Time-out freezing – Selective retransmission – Transaction Oriented TCP.

#### Module-5

6L

Support for Mobility – File Systems – WWW – Wireless Application Protocol.

#### Text Book

1. Jochen Schiller, "Mobile Communications", Pearson Education, Asia Publications, 2000.

#### Reference Book

1. William Stallings, "Wireless Communication and Networks".

### Multimedia and Graphics

#### CSEM206E

Contact: 3L

Credit: 3



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**Module-7**

6L

**Hidden Markov Model:** Introduction, Discrete Markov Processes, Three basic problems of HMM, Learning model parameters, Continuous observations, The HMM with input, Model selection in HMM.

**Recommended Books:**

1. E. Alpaydin, "Introduction to Machine Learning", MIT Press, 2010.
2. T.M. Mitchell, "Machine Learning", McGraw Hill, 1997.
3. M. Mehryar, R. Afshin and T. Ameet, "Foundations of Machine Learning", MIT Press, 2012.
4. S.S. Vinod Chandra and S. Anand H, "Artificial Intelligence and Machine Learning", PHI Learning, 2014.
5. C. Bishop, "Pattern Recognition and Machine Learning", Springer-Verlag, 2006.

**Natural Language Processing****SEM206C****Contact:3L****Credit:3****Allotted Lecture:42****Module-1**

7L

**Introduction:** Need for processing of natural languages, Language processing levels, Applications of NLP, Introduction to Finite State Automata and Regular expressions, Introduction to Formal languages and Context-free grammars.

**Module-2**

7L

**Morphological Processing:** Inflectional and Derivational morphology, Morphological parsing, Finite state transducers, N-gram language models.

**Module-3**

7L

**Part-of-Speech Tagging:** Word Classes, Part-of-speech tagging, Tagsets, Rule-based, Stochastic and Transformation based POS tagging.

**Module-4**

7L

**Parsing:** Basic parsing strategies, Parsing with context-free grammars, Earley algorithm, Finite-state parsing methods, Unification of feature structures.

**Module-5**

7L

**Semantic Analysis:** Lexical Semantics, Lexemes, Relations among lexemes and their senses, WordNet, Word Sense Disambiguation.

**Module-6**

7L

**Pragmatics:** Discourse, Discourse structure. Dialogue - Acts, structure, conversational agents. Language generation, Architecture for generation.



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Introduction, A practical approach, when to believe a result, Structural and Functional interpretation. Analysis packages: Introduction - What is in analysis package? Commercial Databases Comprehensive packages, Packages specializing in DNA analysis. Intranet packages, Internet packages, web addresses.

### Text / Reference Books:

1. Cynthia Gibas & Per Jambeck , “Developing Bio-informatics computer skills”,( O'REILLY)
2. T K Attwood D J Parry-Smith, “Introduction to Bioinformatics”, (Pearson Education)
3. Bryan Bergeron M.D. , “Bioinformatics Computing”, (Prentice-Hall of India)

### Machine Learning

CSEM206B

Contact:3L

Credit:3

Allotted Lecture:

#### Module-1

6L

**Introduction:** Definition of learning systems, Goals and applications of machine learning. Aspects of developing a learning system- Training data, Concept representation, Function approximation, Issues in machine learning. Types of machine learning- Learning associations. Supervised learning - Classification and regression trees, Support vector machines. Unsupervised learning - Clustering, Instance-based learning – Knearest neighbor, Locally weighted regression, Radial basis function, Reinforcement learning.

#### Module-2

6L

**Clustering:** Introduction, Mixture densities, K-means clustering, Expectation maximization algorithm, Hierarchical clustering, choosing the number of clusters.

#### Module-3

6L

**Decision Trees:** Introduction, Univariate trees - Classification and regression. Pruning, Rule extraction from Trees, Learning rules from data, Multivariate trees, Basic decision tree learning algorithm, Issues in decision tree learning.

#### Module-4

6L

**Artificial Neural Networks:** Neurons and biological motivation, Linear threshold units, Perceptrons, Training a perceptron. Multilayer networks and back propagation, Training procedures, Tuning the network size, Bayesian view of learning, Dimensionality reduction, Learning time.

#### Module-5

6L

**Support Vector Machines:** Maximum margin linear separators, Quadratic programming solution to finding maximum margin separators, Kernels for learning non-linear functions.

#### Module-6

6L

**Bayesian Learning and Instance Based Learning:** Probability theory and bayes rule, Naive Bayes learning algorithm, Parameter smoothing, Generative vs. discriminative training, Bayes nets and markov nets for representing dependencies, K-Nearest neighbor algorithm, Case-based learning.



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## **Bioinformatics**

### **CSEM206A**

**Contact:3L**

**Credit:3**

**Allotted Lecture:40**

#### **Module-1**

##### **Introduction:**

8L

Biology in the computer age, computing changes in biology, Bioinformatics just about building database, Meaning of informatics to biologists, challenges offered by biology to computer scientists, skills required for this field, Available information & software for this domain, use web information, understand sequence alignment data, writing programs to align two biological sequences, predict protein structure from sequence, questions bioinformatics can answer, Watson's Definition, Information Flow, Human Genome project.

#### **Module-2**

##### **Tools for Bioinformatics:**

8L

Biological Research on the web, Using search engines, finding scientific articles. Public biological databases, Searching biological databases, Depositing data into the public databases, finding software, Judging the quality of information Sequence Analysis, Pair-wise alignment & Database searching: Chemical composition of bio-molecules, Composition of DNA & RNA, Watson & Crick Solve structure of DNA, Development of DNA sequencing methods, Gene finders & feature detection in DNA, DNA translation, Pair wise sequence comparison, Sequence queries against biological databases, Multifunctional tools for sequence analysis.

#### **Module-3**

##### **Multiple sequence Alignments, Trees & profiles:**

8L

The morphological to the molecular, Multiple sequence alignment, Phylogenic analysis, Profiles & motifs. Predicting protein structure & function from sequence: Determining the structure of the proteins, Prediction the structure of proteins, from 3D to 1D, Feature detection in protein sequences, Secondary structure prediction, Predicting 3D structure.

#### **Module-4**

##### **Tools for Genomic & Proteomics:**

6L

From sequencing genes to sequencing genomes, Sequence assembly, Accessing genome information on the web, Annotating and analyzing whole genome sequences, Functional genomics new data analysis challenges, Proteomics, Biochemical pathway databases, Modeling kinetics & physiology, Visualization and Data Mining: Preparing your data, Viewing graphics, Sequence data visualization, Networks and pathway visualization, working with numerical data, Visualization: summary, Data mining & biological information.

#### **Module-5**

##### **Building a sequence search protocol:**

8L

  
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8. J. P. Uyemura, *Introduction to VLSI Circuits and System*, Wiley, 2002.
9. R. J. Baker, H. W. Li and D. E. Boyce, *CMOS Circuit Design, Layout and Simulation*, PH, 1997.

## **Pattern Recognition**

**CSEM205F**

**Contact:3L**

**Credit:3**

**Allotted Lecture:42**

### **Module-1**

8L

**Introduction:** Definitions, Data sets for pattern recognition, Different paradigms of pattern recognition, Clustering vs Classification, Supervised vs Un-supervised learning, Representations of patterns and classes, Linearly separable patterns and Non-linearly separable patterns, Applications and examples.

### **Module-2**

10L

**Clustering:** Basics of clustering, Sequential algorithm, Similarity and dissimilarity measures, Clustering criteria, Hierarchical algorithms, Functional optimization-based clustering, Graph clustering, Learning clustering, Clustering high dimensional data, Subspace clustering, Cluster validity measures.

### **Module-3**

10L

**Feature Extraction and Selection:** Role of feature extraction and selection in pattern recognition, Feature extraction methods, Non-transformed structural characteristics moments. Transformed signal characteristics- Discrete fourier transform, Discrete cosine and sine transform. Structural descriptors- Graph descriptors. Texture- first-order statistics features, Second-order statistics features, Laws texture energy measures. Shape based features. Feature selection methods – exhaustive search, Branch and bound algorithm, Max-min feature selection and sequential forward and sequential backward selection.

### **Module-4**

10L

**Classifiers:** Role of classifier in pattern recognition, Decision tree, Linear classifier, Quadratic classifier, K-nearest neighbor, Bayesian classifier. Support vector machines (SVMs) – Non-linear SVM classifier, Different kernel functions (Radial Basis function, polynomial). Artificial neural networks (ANNs) for classification and regression, Single layer perceptron, Multi-layer Perceptron, Backpropagation ANN. training set, Test set, Standardization and normalization.

### **Module-5**

4L

**Case Study:** Digit recognition, Character recognition, Pattern recognition applications in bioinformatics and medical imaging.

### **Recommended Books:**

1. C. M .Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
2. S. Marsland, "Machine Learning: An Algorithmic Perspective", CRC Press, 2009.
3. D. Koller and N. Friedman, "Probabilistic Graphical Models", MIT Press, 2009.
4. S. Theodoridis and K. Koutroumbas "Pattern Recognition", Academic Press, 2008.



Fabrication Process flow: basic steps, Fabrication of NMOS Transistor, the CMOS n-Well Process, Layout Design Rules , Full- Custom mask Layout design , CMOS Inverter Layout Design

**Module-2**

6L

**MOS Transistor:** The MOS Structure, Structure and operation of MOSFET, The MOS System under External Bias, The Threshold Voltage, MOSFET Current–Voltage Characteristics, Channel Length Modulation, Substrate Bias Effect, MOSFET Scaling and Small Geometry Effects, Short Channel Effects, Narrow Channel Effects, Limitation Imposed by Small Device Geometries , MOSFET Capacitances.

**Module-3**

5L

**MOS Inverters: Static Characteristics:** CMOS Inverters, Circuit operation, Voltage transfer characteristics of CMOS Inverter, Calculation of  $V_{IL}$ , Calculation of  $V_{IH}$ , Calculation of inverter threshold voltage, Noise Margin.

**Module-4**

6L

**MOS Inverters: Switching Characteristics:** Delay Time Definitions, Calculation of Delay Times, Inverter Design with delay constraints, Estimation of Interconnect Parasitic, Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters.

**Module-5**

4L

**Combinational MOS Logic Circuits:** CMOS Logic Circuits, Layout of simple logic gates, Complex Logic Circuits, Layout of Complex Logic Gates, AOI and OAI Gates, CMOS Transmission Gates (pass gates) , Complementary Pass Transistor Logic.

**Module-6**

4L

**Sequential MOS Logic Circuits:** Behavior of Bitable element, SR Latch Circuits, Clocked Latch and Flip flop Circuits, CMOS D-Latch and Edge Triggered Flip flop , Clocked JK Latch, Master slave Flip flop.

**Module-7**

4L

**Semiconductor Memories:** Dynamic Random Access Memory, DRAM Configuration, Historical Evaluation of DRAM Cell, DRAM Cell Types, operation of one transistor DRAM Cell, DRAM Operation Modes, Static Random Access Memory, Full custom SRAM Cell, CMOS SRAM Design Strategy, Operation of SRAM, Flash Memory NOR Flash Memory Cell, NAND Flash Memory Cell, Flash Memory Circuit.

**Module-8**

4L

**Design for Testability:** Fault Types and Models, Ad Hoc Testable Design Techniques, Scan –based Techniques, Built-In Self Test Techniques.

**REFERENCE BOOKS:**

1. S. M. Kang and Y. Leblebici, *CMOS Digital Integrated Circuits : Analysis and Design*, Third Edition, MH, 2002.
2. W. Wolf, *Modern VLSI Design : System on Chip*, Third Edition, PH/Pearson, 2002.
3. N. Weste, K. Eshraghian and M. J. S. Smith, *Principles of CMOS VLSI Design : A Systems Perspective*, Second Edition (Expanded), AW/Pearson, 2001.
4. J. M. Rabaey, A. P. Chandrakasan and B. Nikolic, *Digital Integrated Circuits: A Design Perspective*, Second Edition, PH/Pearson, 2003.
5. D. A. Pucknell and K. Eshraghian, *Basic VLSI Design: Systems and Circuits*, Third Edition, PHI,
6. 1994.
7. J. P. Uyemura, *CMOS Logic Circuit Design*, Kluwer, 1999.



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Representing simple fact in logic, representing instant & ISA relationship, computable functions & predicates, resolution, natural deduction.

**Module-8** 3L

**Representing knowledge using rules**

Procedural versus declarative knowledge, logic programming, forward versus backward reasoning, matching, control knowledge.

**Module-9** 4L

**Probabilistic reasoning**

Representing knowledge in an uncertain domain, the semantics of Bayesian networks, Dempster-Shafer theory, Fuzzy sets & fuzzy logics.

**Module-10** 2L

**Planning**

Overview, components of a planning system, Goal stack planning, Hierarchical planning, other planning techniques.

**Module-11** 2L

**Natural Language processing**

Introduction, Syntactic processing, semantic analysis, discourse & pragmatic processing.

**Module-12** 2L

**Learning**

Forms of learning, inductive learning, learning decision trees, explanation based learning, learning using relevance information, neural net learning & genetic learning.

**Module** 2L

**Expert Systems**

Representing and using domain knowledge, expert system shells, knowledge acquisition. Basic knowledge of programming language like Prolog & Lisp. [4L]

**Books:**

2. Artificial Intelligence, Ritch & Knight, TMH
3. Artificial Intelligence A Modern Approach, Stuart Russel Peter Norvig Pearson
4. Introduction to Artificial Intelligence & Expert Systems, Patterson, PHI
5. Poole, Computational Intelligence, OUP
6. Logic & Prolog Programming, Saroj Kaushik, New Age International
7. Expert Systems, Giarranto, VIKAS
8. Artificial Intelligence, Russel, Pearson

**VLSI Design**

**CSEM205E**

**Contact:3L**

**Credit:3**

**Allotted Lecture:40**

**Module-1** 7L

**Introduction:** Overview of VLSI design Methodologies, VLSI Design flow, Design Hierarchy, Concept of Regularity, Modularity, and Locality, VLSI design styles **Fabrication of MOSFETs:**

1. J. P. Tremblay and P. G. Sorrenson, "The Theory and Practice of Compiler Writing", McGraw Hill, 1985

## **Artificial Intelligence**

### **CSEM205D**

**Contact:3L**

**Credit:3**

**Allotted Lecture:36**

#### **Module-1**

**Introduction:** 2L

Overview of Artificial intelligence- Problems of AI, AI technique, Tic - Tac - Toe problem.

#### **Module-2**

2L

##### **Intelligent Agents**

Agents & environment, nature of environment, structure of agents, goal based agents, utility based agents, learning agents.

#### **Module-3**

**Problem Solving** 2L

Problems, Problem Space & search: Defining the problem as state space search, production system, problem characteristics, issues in the design of search programs.

#### **Module-4**

4L

##### **Search techniques**

Solving problems by searching problem solving agents, searching for solutions; uniform search strategies: breadth first search, depth first search, depth limited search, bidirectional search, comparing uniform search strategies.

#### **Module-5**

3L

##### **Heuristic search strategies**

Greedy best-first search, A\* search, memory bounded heuristic search: local search algorithms & optimization problems: Hill climbing search, simulated annealing search, local beam search, genetic algorithms; constraint satisfaction problems, local search for constraint satisfaction problems.

#### **Module-6**

3L

##### **Adversarial search**

Games, optimal decisions & strategies in games, the minimax search procedure, alpha-beta pruning, additional refinements, iterative deepening.

#### **Module-6**

3L

##### **Knowledge & reasoning**

Knowledge representation issues, representation & mapping, approaches to knowledge representation, issues in knowledge representation.

#### **Module-7**

2L

**Using predicate logic**



**Module-4** 9L  
Authentication applications – Kerberos, X.509, PKI – Electronic Mail security – PGP, S/MIME – IP security – Web Security – SSL, TLS, SET.

**Module-5:** 9L  
System security – Intruders – Malicious software – viruses – Firewalls – Security Standards.

**Text Books:**

1. Wade Trappe, Lawrence C Washington, “ Introduction to Cryptography with coding theory”,
2. 2nd ed, Pearson, 2007.
3. William Stallings, “Cryptography and Network security Principles and Practices”, Pearson/PHI, 4<sup>th</sup> ed, 2006.

**REFERENCES:**

1. W. Mao, “Modern Cryptography – Theory and Practice”, Pearson Education, Second Edition, 2007.
2. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing Third Edition – Prentice Hall of India, 2006

**Advanced Compiler Design**  
**CSEM205C**

**Contact:3L**

**Credit:3**

**Allotted Lecture:40**

**Module – 1** 8L  
Introduction - Structure of a compiler - Different phases of a compiler - Finite automata and lexical analysis.

**Module– 2** 8L  
Syntactic specification - Context-free grammars - Derivation and parse trees - Basic parsing techniques.

**Module– 3** 8L  
LR Parsers - SLR, Canonical LR and LALR - Syntax-directed translation schemes – Various forms of intermediate code.

**Module-4** 8L  
Translation of array references: procedure calls, declarations and case statements - Symbol tables - Run-time storage administration - Error detection and recovery.

**Module-5** 8L  
Code Optimization - Loop optimization - DAG representation of basic blocks - Code generation from DAG's - Compiler compilers: YACC - Attributed parser generators.

**Text Book**

1. A. V. Aho, R. Sethi, and J. D. Ullman, "Compilers, Principles, Techniques and Tools", Pearson Education, 13th Indian Reprint, 2003

**Reference Book**



Mobile telephone systems: introduction to wireless networks and cellular technology, AMPS, D-AMPS, GSM, GPRS, CDMA, Bluetooth.

**Module-5** 4L  
Wireless networks: WLAN: Introduction, problems and solutions, protocol stack, access methods, services, WIMAX, WIFI, and ZIGBEE.

**Module-6** 4L  
Ad-hoc networks: Introduction, Routing challenges for ad-hoc networks, Routing protocols (AODV, DSDV, DSR,), Transport protocols (ATCP, TCP-F, TCP BUS).

**Module-7** 4L  
Wireless Internet: MIPV4, MIPV6, TCP Performance, I-TCP, TCP SNOOP, FREEZE TCP, WWP, TCP REAL.

**Module-8** 4L  
Congestion control: General Principles, Congestion prevention policies, Choke packet, RED, ECN, ELN, ELN-ACK. [4 L]

**Module-9** 4L  
QOS provisioning: delay guarantees, network delay, delay jitter, and play out delay, admission control, QOS objectives, the RSVP approach.

**Module-10** 6L  
Security: Introduction to Cryptography, Symmetric key and Public key algorithms, Diffie Hellman key exchange algorithm, Digital signatures, IPsec, firewall, VPN, VLAN, wireless security, Authentication protocols.

### Text Books

1. Internetworking with TCP/IP: Principles, Protocols, and architecture – Douglas Comer.
2. Computer networks –A.S.Tannenbaum.
3. Data and Computer Communications – William Stallings
4. Wimax security & QOS-an end-to-end perspective, Wiley publication.

### Distributed Systems

#### CSEM205A

**Contact:**

**Credit:**

**Allotted Lecture:**

#### Module-1:

##### Distributed Systems

9L

Computer architecture: CICS, RISC, Multi-core Computer networking: ISO/OSI Model Evolution of operating systems Introduction to distributed computing systems. DCS design goals, Transparencies, Fundamental issues.

#### Module- 2:

##### Distributed Coordination

7L

Temporal ordering of events, Lamport's logical clocks, Vector clocks; Ordering of messages, Physical clocks, Global state detection



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Process Management and Synchronization - The Critical Section Problem, Synchronization Hardware, Semaphores, and Classical Problems of Synchronization, Critical Regions, Monitors.

**Module-4**

5L

Operating System Security Issues- Introduction to the topic of Security in Operating Systems, Principles of Information Security, Access Control Fundamentals, Generalized Security Architectures.

**Module-5**

5L

Introduction to Distributed systems: Goals of distributed system, hardware and software Concepts, design issues. Elementary introduction to the terminologies within Modern Oss: Parallel, Distributed, Embedded & Real Time, Mobile, Cloud and Other Operating System Models.

**Text books**

1. Operating System Principles- Abraham Silberchatz, Peter B. Galvin, Greg Gagne 7th Edition, John Wiley
2. Distributed Operating System - Andrew. S. Tanenbaum, PHI
3. Operating System a Design Approach-Crowley, TMH.
4. Operating Systems – Internals and Design Principles Stallings, Fifth Edition–2005, Pearson Education/PHI
5. Modern Operating Systems, Andrew S Tanenbaum 2nd edition Pearson/PHI
6. Operating Systems, Dhamdhere, TMH
7. Tanenbaum, Modern Operating Systems, 2nd ed.
8. Silberschatz & Galvin, Operating System Concepts, 6th ed.
9. Saltzer & Kaashoek, Principles of Computer System Design, 2009
10. Coulouris et al., Distributed Systems: Concepts and Design, 3rd ed., - Lynch,
11. Distributed Algorithms, - Lynch et al., Atomic Transactions,
12. Casevant & Singhal, Readings in Distributed Computing Systems,
13. Ananda & Srinivasan, Distributed Computing Systems: Concepts and Structures Mullender, Distributed Systems
14. Filman & Friedman, Coordinated Computing: Tools and Techniques for Distributed Software, - Andrews, Concurrent Programming: Principles and Practice.

**Advanced Computer Network & Security**

**CSEM204**

**Contact: 4L**

**Credit:4**

**Allotted Lecture:44**

**Module-1**

6L

Introduction to internetworking: how networks differ, how networks can be connected, connectionless internetworking, tunneling, fragmentation, overview of underlying technologies (Ethernet, token ring, token bus, FDDI, PPP).

**Module-2**

4L

Network layer protocols: IPV4, IPV6, NAT, ARP, RARP, DHCP, ICMP, OSPF, BGP, IGMP, CIDR.

**Module-3**

4L

Transport layer protocols: UDP, remote procedure call, RTP, TCP, TCP Tahoe, TCP Reno, TCP new Reno, TCP Stack.

**Module-4**

4L

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**Module-3:****Process synchronization**

6L

Distributed mutual exclusion algorithms, Performance matrix.

**Module-4:****Inter-process communication**

6L

Message passing communication, Remote procedure call, Transaction communication, Group communication; Broadcast atomic protocols.

**Module-5:****Distributed file systems**

6L

Deadlocks in distributed systems and Load scheduling and balancing techniques.

**Text Books:**

1. Distributed Systems Concepts and Design, G. Coulouris, J. Dollimore, Addison Wesley
2. Advanced Operating Systems, M. Singhal, N.G. Shivarathri, McGraw Hill
3. Distributed Operating Systems and Algorithms, Randy Chow, T. Johnson, Addison Wesley
4. Distributed Operating Systems, A.S. Tanenbaum, Prentice Hall
5. Principles of Distributed Database Systems, M. Tamer Ozsu, Patrick Valduriez, Prentice Hall International
6. Tanenbaum, A. S. Distributed Operating Systems, Prentice Hall 1995. Tanenbaum, A. S. Modern Operating Systems, 2nd Edition, Prentice Hall 2001.
7. Bacon, J., Concurrent Systems, 2nd Edition, (ISBN 0-201-177-676), Addison Wesley 1998.
8. Silberschatz, A., Galvin, P. and Gagne, G., Applied Operating Systems Concepts, 1st Edition, Wiley 2000.
9. Coulouris, G. et al, Distributed Systems: Concepts and Design, 3rd Edition, Addison Wesley 2001.
10. Galli, D.L., Distributed Operating Systems: Concepts and Practice Prentice-Hall 2000.

**Cryptography & Network Security****CSEM205B****Contact:3L****Credit:3****Allotted Lecture:45****Module-1**

9L

Security trends – Attacks and services – Classical crypto systems – Different types of ciphers – LFSR sequences – Basic Number theory – Congruences – Chinese Remainder theorem – Modular exponentiation – Fermat and Euler's theorem – Legendre and Jacobi symbols – Finite fields – continued fractions.

**Module-2:**

9L

Simple DES – Differential cryptanalysis – DES – Modes of operation – Triple DES – AES – RC4 – RSA – Attacks – Primality test – factoring.

**Module-3**

9L

Discrete Logarithms – Computing discrete logs – Diffie-Hellman key exchange – ElGamal Public key cryptosystems – Hash functions – Secure Hash – Birthday attacks - MD5 – Digital signatures – RSA – ElGamal – DSA.



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**Module-3:**

12L

RISC architecture, characteristics of RISC instruction set & RISC pipeline, its comparisons with CISC, necessity of using optimizing compilers with RISC architecture, Examples from POWER PC and SPARC architectures, Super pipelining (MIPS architecture), Superscalar architecture, Diversified pipelines and out of order execution, VLIW architecture, Hardware multithreading (Coarse grained, fine grained & simultaneous multithreading).

**Module-4:**

6L

Memory hierarchy – Techniques for improving Cache memory performance parameters, (reduce cache miss rate, reduce hit time, reduce miss penalty), Main memory performance enhancement – interleaved memory, improvement of memory bandwidth, use of TLB for performance enhancement.

## Text books:

1. Computer Organization & Design – Patterson & Hennessy (Morgan Kaufmann)
2. Computer Architecture: A Quantitative Approach – Patterson & Hennessy (Elsevier)
3. Computer Architecture & Parallel Processing – Hwang & Briggs (TMH)
4. Computer organization and architecture, designing for performance – Stallings (PHI)
5. Modern Processor Design – Shen & Lipasti (TMH)
6. Advanced Computer Architecture – Hwang (TMH)
7. An Introduction to Intel family of Microprocessors – Antonakos (Pearson)
8. Computer Architecture – Flynn (Narosa)
9. Structured Computer Organization – Tanenbaum (PHI)
10. Computer Architecture & Organization – J P Hayes (McGraw Hill)
11. Computer Organization – Hamacher, Vranesic, Zaky (McGraw Hill)

**Advanced Operating System****CSEM203****Contact: 4L****Credit: 4****Allotted Lecture: 40****Module-1:**

4L

Operating System Introduction, Structures - Simple Batch, Multi programmed, time-shared, Personal Computer, Parallel, Distributed Systems, Real-Time Systems, System components, Operating-System services, System Calls, Virtual Machines, System Design and Implementation.

5L

Process and CPU Scheduling - Process concepts and scheduling, Operation on processes, Cooperating Processes, Threads, and Interposes Communication Scheduling Criteria, Scheduling Algorithm, Multiple -Processor Scheduling, Real-Time Scheduling.

**Module-2**

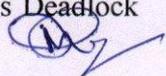
12L

Memory Management and Virtual Memory - Logical versus Physical Address Space, Swapping, Contiguous Allocation, Paging, Segmentation, Segmentation with Paging. Demand Paging, Performance of Demanding Paging, Page Replacement, Page Replacement Algorithm, Allocation of Frames, Thrashing. File System Interface and Implementation -Access methods, Directory Structure, Protection, File System Structure, Allocation methods, Free-space Management, Directory Management, Directory Implementation, Efficiency and Performance.

**Module-3**

9L

Deadlocks - System Model, Dead locks Characterization, Methods for Handling Deadlocks Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, and Recovery from Deadlock.

  
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**Module-6:** Sampling distributions: 2L  
Chi-Square Distribution, t-Distribution, and F-Distribution.

**Module-7:**  
Parametric Point estimation: 5L  
Methods of Finding Estimators Method of Moments, Maximum Likelihood Estimators Methods of Evaluating Estimators Mean Squared Error, Best Unbiased Estimators, Sufficiency and Unbiasedness.

**Module-8:**  
Hypothesis Testing: 3L  
Concepts of Hypothesis Testing, Neyman-Pearson lemma, Likelihood Ratio Test, and Confidence Intervals.

**Text Books:**

1. V. Rohatgi, A. Saleh, Introduction to Probability Theory and Statistics, Second Edition, Wiley-Interscience, 2000.
2. W. Feller, An Introduction to Probability Theory and Its Applications, Vol.1, Third Edition, Wiley, 1968.
3. G. Casella, R. L. Berger, Statistical Inference, Second Edition, Duxbury Press, 2001.
4. J. S. Rosenthal, A First look at Rigorous Probability Theory, Second Edition, World Scientific, 2006.

**Advanced Computer Architecture**

**CSEM202**

**Contact: 4L**

**Credit: 4**

**Allotted Lecture: 42**

**Module-1:** 4L

The evolution of modern Computer systems – from DEC PDP-11, IBM 360/370 family, CDC Cyber 6600, Intel X86 architecture, Performance measurement parameters – MIPS, MFLOPS, SPEC ratings, CPI etc.

8L  
Introduction to high performance Computing – Overview, Flynn's classifications – SISD, SIMD, MISD, MIMD, Examples from Vector & Array Processors, Performance comparison of algorithms for Scalar, Vector and Array Processors, Fundamentals of UMA, NUMA, NORMA architectures, Performance measurement for parallel architectures – Flynn's measure, Feng's measure, Handler's measure, Amadahl's law of limitation for parallel processing, Gustafson's law.

**Module -2:** 12L

Pipelined processor design, Pipeline performance measurement parameters – speedup factor, efficiency, throughput of a linear pipeline, comparing performance of a N stage pipeline with a N processor architecture, Pipeline design principles – Uniform sub computations, Identical computations, Independent computations, Examples from design of Arithmetic pipelines – Floating point Adders, Multipliers, Dividers etc., Classifications of Unification, Multifunction & Dynamic pipelines, Scheduling in a pipelines with feedback, Pipeline hazards and their solutions

Lab 10: Greedy method (implement any one of the following problem): Minimum Cost Spanning Tree by Prim's Algorithm Minimum Cost Spanning Tree by Kruskal's Algorithm

Lab 11: Graph Traversal Algorithm: Implement Breadth First Search (BFS), Implement Depth First Search (DFS)

### Database Lab

Code: CSEM194

Credit: 3

Contacts: 3P

Allotted Lecture: 33P

### Experiments

Exercises to be based on Sybase / Oracle / Postgres / VB / Power Builder / DB2 / MS Access. Applications involving vendor development systems, stores management system, finance management etc.

Creation and querying of database tables

Design of tables by normalization and dependency analysis

Writing application software with host language interface

### Probability and Statistic for Engineer

Subject Code: CSEM201

Contact: 40

Credit: 4

Total Lecture Hours: 40

#### Module-1:

Probability:

8L

Sample Space, Axioms of Probability, Probability on Finite Sample Spaces, Conditional Probability, Bayes Theorem, and Independence of Events.

#### Module-2:

Random Variables:

7L

Random Variables, Probability Distribution of a Random Variable, Discrete and Continuous Random Variables, and Functions of a Random Variable.

#### Module-3:

Moments and Generating Functions:

5L

Moments of a Distribution Function, Generating Functions, and Some Moment Inequalities.

#### Module-4:

Multiple Random Variables:

5L

Multiple Random Variables, Independent Random Variables, Functions of Several Random Variables, Covariance, Correlation, Moments, Conditional Expectation, Order Statistics and Their Distributions.

#### Module-5:

Limit theorems:

5L

Modes of convergence weakly, in distribution, in probability, almost sure, and their relationship, Weak law of large numbers Strong law of large numbers, Borel-Cantelli lemma, and Central limit theorem.

Point set triangulations, basic definition and properties randomize incremental algorithm and analysis.

**Module IX: [4L]**

**Arrangements and Duality**

Point/line duality, incremental construction of arrangements and the zone-theorem, applications.

**Module X: [4L]**

**Geometric Approximation**

Dudley's theorem and applications, well-separated pair decompositions and geometric spanners, VC dimension, epsilon-nets and epsilon-approximations,

**Module XI: [4L]**

**Geometric Retrieval**

kd-trees, range trees, hereditary segment trees, nearest neighbor searching.

**Text Book:**

1. Computational Geometry: Algorithms and Applications (2nd Edition), M. de Berg, M. van Kreveld, M. Overmars, O. Schwarzkopf, Springer-Verlag, 2000.

**Algorithm Lab**

**Code: CSEM193**

**Credit: 3**

**Contacts: 3P**

**Allotted Lecture: 33P**

Programming Language to be used: C

Lab 1: Divide and Conquer: Implement Binary Search using Divide and Conquer approach and analysis, Implement Merge Sort using Divide and Conquer approach,

Lab 2: Divide and Conquer: Implement Quick Sort using Divide and Conquer approach, Find Maximum and Minimum element from a array of integer using Divide and Conquer approach

Lab 3: Dynamic Programming: Find the minimum number of scalar multiplication needed for chain of matrix

Lab 4: Dynamic Programming: Implement all pair of Shortest path for a graph ( Floyd- Warshall Algorithm ), Implement Traveling Salesman Problem

Lab 5: Dynamic Programming: Implement Single Source shortest Path for a graph ( Dijkstra , Bellman Ford Algorithm )

Lab 6: Brunch and Bound: Implement 15 Puzzle Problem

Lab 7: Backtracking: Implement 8 Queen problem

Lab 8: Backtracking (implement any one of the following problem): Graph Coloring Problem Hamiltonian Problem

Lab 9: Greedy method (implement any one of the following problem): Knapsack Problem Job sequencing with deadlines

Genetic Algorithm for Optimization, Applications.

**Text Books:**

1. "An Introduction to Genetic Algorithm", Mitchell Melanie, Prentice Hall, 1998.
2. "Genetic Algorithms in Search, Optimization and Machine Learning", David E. Goldberg, Addison Wesley, 1997.
3. "Neural Networks", S. Haykin, Pearson Education, 2ed, 2001.
4. "Neural Networks, Fuzzy logic, and Genetic Algorithms", S. Rajasekaran & G. A. V. Pai, PHI.
5. "Fuzzy Sets and Fuzzy Logic", Klir & Yuan, PHI, 1997
6. "Rough Sets", Z. Pawlak, Kluwer Academic Publisher, 1991.
7. "Neural Networks, Fuzzy logic, and Genetic Algorithms", S. Rajasekaran and G. A. V. Pai, PHI.
8. "Intelligent Hybrid Systems", D. Ruan, Kluwer Academic Publisher, 1997.

**Computational Geometry**

**Code: CSEM106G**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 42L**

**Module I: [4L]**

**Preliminaries**

Basic Euclidean geometry, Geometric Preliminaries, Data Structures for geometric problems: DCEL (Doubly Connected Edge List), Quad trees, Kd-trees and BSP ( Binary Space Partition) trees.

**Module II: [3L]**

**Grids and Hulls**

Fixed-radius near neighbors, Convex Hulls, Convex Hull Algorithms in the Plane -- Graham's Scan Algorithm, Jarvi's March, Divide and Conquer Algorithm, Quick Hull Algorithm. Triangulation— Polygon Triangulation, dominance and applications.

**Module III: [3L]**

**Linear Programming**

Half-plane intersection and randomized LP, backwards analysis, applications of low-dimensional LP.

**Module IV: [4L]**

**Intersections and Triangulation**

Plane-sweep line segment intersection, triangulation of monotone subdivisions, plane-sweep triangulation of simple polygons.

**Module V: [4L]**

**Point Location**

Kirkpatrick's method, trapezoidal decompositions and analysis, history DAGs.

**Module VI: [4L]**

**Voronoi Diagrams**

Basic definitions and properties, Fortune's algorithm.

**Module VII: [4L]**

**Geometric Data Structures**

kd-trees, range trees and range searching, segment trees.

**Module VIII: [4L]**

**Delaunay Triangulations**



### **Simulation Tools**

Basic introduction to simulation tools - Scilab, Tortuga and Extend. Introduction to network simulators - NS2, CloudSim, Wireshark.

### **Text Books:**

1. "Discrete- event system and simulation", J. Banks, J.S. Carson II, B. L. Nelson and D. M. Nicol, Prentice Hall of India, 2010.
2. "Simulation Modeling and Analysis", A. M. Law, Tata McGraw Hill India, 2007.
3. "Discrete-event modeling and simulation: a practitioner's approach", G.A. Wainer, CRC Press, 2009.

### **Reference Books:**

1. "Theory of modeling and simulation: integrating discrete event and continuous complex dynamic systems", B.P. Zeiger, H. Praehofer and T. G. Kim, Academic Press, 2000.
2. "Modeling and simulation: theory and practice", W. J. Karplus, G. A. Bekey and B. YakobKogan, Springer, 2003.

### **Soft Computing**

**Code: CSEM106F**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 40L**

### **Module I: [8L]**

#### **Introduction to Soft Computing**

Evolution of Computing - Soft Computing Constituents – From Conventional Artificial Intelligence to Computational Intelligence - Machine Learning Basics.

### **Module II: [8L]**

#### **Fuzzy Logic**

Fuzzy sets and Fuzzy logic: Introduction, Fuzzy sets versus crisp sets, operations on fuzzy sets, Extension principle, Fuzzy relations and relation equations, Fuzzy numbers, Linguistic variables, Fuzzy logic, Linguistic hedges, Applications, fuzzy controllers, fuzzy pattern recognition, fuzzy image processing, fuzzy database.

### **Module III: [8L]**

#### **Artificial Neural Networks**

Artificial Neural Network: Introduction, basic models, Hebb's learning, Adeline, Perception, Multilayer feed forward network, Back propagation, Different issues regarding convergence of Multilayer Perceptron, Competitive learning, Self-Organizing Feature Maps, Adaptive Resonance Theory, Associative Memories, Applications.

### **Module IV: [8L]**

#### **Genetic Algorithms**

Evolutionary and Stochastic techniques: Genetic Algorithm (GA), different operators of Genetic Algorithm, Analysis of selection operations, Hypothesis of building Blocks, Schema theorem and convergence of Genetic Algorithm, Simulated annealing and Stochastic models, Boltzmann Machine, Applications. Rough Set: Introduction, Imprecise Categories Approximations and Rough Sets, Reduction of Knowledge, Decision Tables, and Applications.

### **Module V: [8L]**

#### **Hybrid Systems**

Neural-Network-Based Fuzzy Systems, Fuzzy Logic-Based Neural Networks, Genetic Algorithm for Neural Network Design and Learning, Fuzzy Logic controlled Genetic Algorithm. Fuzzy Logic and

communication mechanisms – Performance issues.

**Module IV: [9L]**

**Embedded Software**

Programming embedded systems in assembly and C – Meeting real time constraints – Multi-state systems and function sequences. Embedded software development tools – Emulators and debuggers.

**Module V: [9L]**

**Embedded System Development**

Design issues and techniques – Case studies – Complete design of example embedded systems.

**Text Books:**

1. “Computers as Components: Principles of Embedded Computer System Design”, Wayne Wolf, Elsevier, 2006.
2. “Embedded C”, Michael J. Pont, Pearson Education , 2007.

**Reference Books:**

1. “Embedded System Design”, Steve Heath, Elsevier, 2005.
2. “The 8051Microcontroller and Embedded Systems”, Muhammed Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, Pearson Education, Second edition, 2007.

**Modeling and simulation**

**Code: CSEM106E**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 40L**

**Module I: [4L]**

**Introduction**

Modeling concepts and definitions, System models and role of simulation, Types of models, Discrete-event simulation, Steps in a simulation study, Simulation examples.

**Module II: [10L]**

**Statistical Models in Simulation**

Basics of statistical model, Discrete and continuous distribution, Poisson processes and empirical distribution, Elementary queuing theory, Queuing models involving non-exponential distribution, Queuing models involving hyper- exponential distribution, Queuing models without a poisson input, Priority discipline queuing model, Queuing networks, Application of queuing models.

**Module III: [8L]**

**Random Number Generation**

Properties of random numbers, Generation of pseudo random numbers, Random variate generation, Techniques for generation of pseudo random numbers - Mid-square random number generator, Residue method, Arithmetic congruential generator, Hypothesis testing and tests for random numbers.

**Module IV: [10L]**

**Input Modeling and Output analysis**

Data collection, Identifying the distribution of data- histograms and Quantile-Quantile plots. Parameter estimation, Goodness of fit tests applied to simulation inputs, Output analysis and measures of performance and estimation.

**Module V: [8L]**



Communication overheads, Single/multiple program performances, Bench marks.

**Module III: [8L]**

**Parallel Computer Models**

Elements of modern computers, System attributes to performance, Shared memory multiprocessors, Distributed memory multicomputers, Loosely and tightly coupled multiprocessors, Multivector computers, PRAM models, Interconnection networks.

**Module IV: [8L]**

**Pipelining and Superscalar Techniques**

Linear pipeline processors – Asynchronous and synchronous models, Clocking and timing control, Nonlinear pipeline processors, Reservation and latency analysis, Collision-Free scheduling, Pipeline schedule optimization. Instruction pipeline design - Instruction execution phases, Mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch handling techniques, Pipeline hazards.

**Module V: [8L]**

**Basic Parallel Algorithmic Techniques and Programming**

Pointer jumping, Divide and Conquer, Partitioning, Pipelining, Accelerated cascading, Symmetry breaking, Synchronization (Locked, Lock-free) parallel algorithms. Programming systems - Pthreads, OpenMP, MPI and global address space languages.

**Text Books:**

1. "Computer Architecture and Parallel Processing", F. A. Briggs, McGraw-Hill International Editions, 1984.
2. "Parallel Programming in C with MPI and OpenMP", M. J. Quinn, McGraw-Hill, 2003.
3. "Computer Systems Organization and Architecture", J. d. Carpinelli, Addison Wesley, 2001.
4. "Introduction to Parallel Computing", A. Grama, G. Karypis, V. Kumar and A. Gupta, Addison-Wesley, 2003.

**Embedded Systems**

**Code: CSEM106D**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 45L**

**Module I: [9L]**

**Embedded Computing**

Challenges of Embedded Systems – Embedded system design process. Embedded processors – 8051 Microcontroller, ARM processor – Architecture, Instruction sets and programming.

**Module II: [9L]**

**Memory and Input / Output Management**

Programming Input and Output – Memory system mechanisms – Memory and I/O devices and interfacing – Interrupts handling.

**Module III: [9L]**

**Processes and Operating Systems**

Multiple tasks and processes – Context switching – Scheduling policies – Interprocess

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

#### **Module VII: [8L]**

##### **Computational Complexity**

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

#### **Module VIII: [4L]**

**Logic:** Propositional and First-order logic and their applications to theorem proving and logic programming.

#### **Module IX: [6L]**

**Advanced/Emerging areas:** Elementary introductions to DNA Computing, Quantum Computing, Cellular Automata, Circuit complexity, Structural Complexity, Parallel Complexity, Algorithmic Information. Course Guidelines: Large majority of the lectures would focus only on the core areas, with only elementary introduction to other remaining advanced areas.

#### **Text Books:**

1. "Introduction to Automata Theory Language and Computation", Hopcroft H.E. and Ullman J. D., Pearson Education.
2. "Theory of Computer Science ", Automata Languages and computation", Mishra and Chandrashekar, 2nd edition, PHI.
3. "Formal Languages and Automata Theory", C.K.Nagpal, Oxford

#### **Reference Books:**

- 1 "Switching & Finite Automata", ZVI Kohavi, 2nd Edn., Tata McGraw Hill
2. "Introduction to Computer Theory", Daniel I.A. Cohen, John Wiley
3. "Introduction to languages and the Theory of Computation", John C Martin, TMH
4. "Elements of Theory of Computation", Lewis H.P. & Papadimitrou C.H. Pearson, PHI.

### **Parallel Computing**

**Code: CSEM106C**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 40L**

#### **Module I: [8L]**

##### **Introduction**

Basic uniprocessor architecture, Parallel computer. Need of parallel computers, models of computation, Analyzing algorithms. Multiprogramming and time sharing, Pipeline computers, Multiprocessor systems, Serial versus parallel processing. Parallelism approaches – Data parallelism, Control parallelism. Hardware taxonomy–Flynn's classifications, Handler's classifications, Parallel processing applications.

#### **Module II: [8L]**

##### **Performance Metrics**

Laws governing performance measurements. Metrics - Speedups, Efficiency, Utilization,

## Reference Books:

1. "Java Servlets Programming", Jason Hunter and William Crawford, O'Reilly Publications, 1998.
2. "Java Script", Jeff Frantzen and Sobotka, Tata McGraw Hill, 1999.
3. "Using HTML 4, XML and Java", Eric Ladd and Jim O'donnell, Prentice Hall of India – QUE, 1999. CSE Dept. OBE Curriculum NITTUGCSE08 46.

## Theory of Computation

**Code: CSEM106B**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 46L**

### Module I: [5L]

#### Finite Automata

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

### Module II: [4L]

#### Regular expression and Languages

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

### Module III: [4L]

#### Context Free Languages

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

### Module IV: [5L]

#### Push Down Automata

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

### Module V: [4L]

#### Turing Machine

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

### Module VI: [6L]

#### Computability and Decidability



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graphing.

**Text Books:**

1. "Software Engineering - A Practitioner's Approach", Roger Pressman, Mcgraw Hill, New York.
2. "Software Engineering", Ian Sommerville, Addison-Wesley Publishing Company, England

**Reference Books:**

1. "An Integrated Approach To Software Engineering", Pankaj Jalote, Narosa Publishing House, New Delhi.
2. "The Unified Modeling Language User Guide", Grady Booch, James Rumbaugh, Ivar Jacobson, Pearson Education, New York.

**Web Technology**

**Code: CSEMI06A**

**Credit: 3**

**Contacts: 3L**

**Allotted Lecture: 42L**

**Module I: [8L]**

Internet Principles – basic web concepts – Client/ server model – Retrieving data from Internet – Internet Protocols and applications

**Module II: [8L]**

HTML forms – HTML tags emulation – Links and addressing- HTML and Images

**Module III: [8L]**

Streaming – Networking Principles – Sockets for Clients – Sockets for Servers – Protocol Handlers – Content Handlers – Multicast sockets -- Remote method Invocation.

**Module IV: [6L]**

Scripts - Java Script, VB Script, DHTML, XML, CGI, Servlets.

**Module V: [6L]**

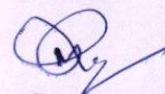
Server Scripts - Java Sever Pages (JSP), Active Server pages (ASP), Simple applications – Online databases – Monitoring user events – Plug-ins – Database connectivity.

**Module VI: [6L]**

Introduction to Semantic Web – layered approach - web documents in XML – schema - name space – querying - processing. RDF - Schema – Web Resource Description using RDF- RDF Properties – Topic Maps and RDF – axiomatic semantics of RDF and RDF schema – inference system RQL and querying. Logic and inference – monotonic rules – syntax and semantics – non-monotonic rules – examples – rule mark-up in XML. Querying with SPARQL.

**Text Books:**

1. "Java Network Programming", Eillotte Rusty Harold, O'Reilly Publications, 1997.
2. "Internet & World Wide Web How to Program", Harvey M. Deitel and Paul J. Deitel, 4<sup>th</sup> edition, 2008.
3. "Web Technology – A Developer's Perspective", N. P. Gopalan and J. Akilandeswari, PHIO Pvt Ltd., New Delhi-, 2007.
4. Grigoris Antoniou, Frank van Harmelen, "A Semantic Web Primer (Cooperative Information Systems)" , The MIT Press, 2009



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3. "Fundamentals of Database Systems", R. Elmasri, S. Navathe, Pearson Education, 2007.

## **Software Engineering & Case Tools**

**Code: CSEM105**

**Credit: 4**

**Contacts: 4L**

**Allotted Lecture: 40L**

### **Module I: [8L]**

#### **Principles and Motivations**

Definitions And Need For Engineered Approach To Software Development; Software development Process Models From The Points Of View Of Technical Development And Project Management: Waterfall, Rapid Prototyping, Incremental Development, Spiral

### **Module II: [8L]**

#### **Models and Emphasis on Computer-Assisted Environments.**

Introduction to Modeling Tools Basics Of Object-Oriented Approach, Object-Oriented Programming And Languages, Omt, Visual Modeling, Uml, Rational Rose Tool

### **Module III: [8L]**

#### **Software Development Methods**

Formal, Semi-Formal And Informal Methods; Requirements Elicitation, Requirements Specification; Data, Function, And Event-Based Modeling; Some Of The Popular Methodologies Such As Yourdon's Sad, Ssadm Etc; Case Tools-Classification, Features, Strengths And Weaknesses; Icase; Case Standards.

### **Module IV: [6L]**

#### **Software Project Management**

Principles Of Software Projects Management; Organizational And Team Structure; Project Planning; Project Initiation And Project Termination; Technical, Quality, And Management Plans; Project Control; Cost Estimation Methods - Function Points and Cocomo.

### **Module V: [5L]**

#### **Object Modeling and Design**

Classes, Objects, Relationships, Key Abstractions, Common Mechanisms, Diagrams, Class Diagrams, Advanced Classes, Advanced Relationships, Interfaces, Types, Roles, Packages, Instances, Object Diagrams, Interactions, Use Cases, Use Case Diagrams, Interaction Diagrams, Activity Diagrams, Events And Signals, State Machines, Processes, Threads, State Chart Diagrams, Components, Deployment, Collaborations, Patterns And Frameworks, Component Diagrams, Systems And Models, Code Generation And Reverse Engineering.

### **Module VI: [5L]**

#### **Software Testing**

Software Testing Strategy and Environment Establishing testing policy, structured approach to testing, test factors, Economics of System Development Life Cycle (SDLC) Testing Software Testing Methodology Defects hard to find, verification and validation, functional and structural testing, workbench concept, eight considerations in developing testing methodologies, testing tactics checklist, Software Testing Techniques Black Box, Boundary value, Bottom up, Branch coverage, Cause Effect

## Reference Books:

1. "Fundamentals Of Algorithms"- G.Brassard, P.Bratlay, Phi.
2. "Fundamentals Of Computer Algorithms", Horowitz Ellis, Sahani Sartaz, R. Sanguthevar.

## Databases and Data Mining

Code: CSEM104

Credit: 4

Contacts: 4L

Allotted Lecture: 40L

### Module I: [8L]

#### Database Management System (DBMS)

Database System Architectures: Centralized and Client-Server Architectures, Server System Architectures, Distributed Systems. Query Processing Algorithms – Query Optimization Techniques – Transaction Management: Transaction Processing Concepts - Concurrency Control, Deadlocks Recovery Techniques. Distributed Database – Functions – Distributed RDB design- Transparency– Distributed Transactions - Commit Protocols – Concurrency Control –Deadlocks – Recovery.

### Module II: [8L]

#### Object Oriented Database Management System (OODBMS)

Concepts of OODBMS, Storing objects in relational database, Object oriented data models and DBMS, Issues in OODBMS, Advantages and disadvantages of OODBMS. **Spatial and Temporal Data and Mobility:** Motivations, Terms in databases, Spatial and geographic data, Multimedia database, Mobility and personal databases.

### Module III: [8L]

#### Data Warehousing and OLAP

Introduction to data warehousing, Data ware architecture, Data flows, warehousing tools, Data marts, Data warehouse design, Online Analytical Processing (OLAP benchmarks, benefits, representation of multi-dimensional data applications of OLAP, OLAP tools, categories of OLAP tools).

### Module IV: [8L]

#### Data Mining

Introduction, Process of data mining, Data mining goals, Tasks and techniques (Prediction modeling, Database segmentation, Link analysis, Deviation detection), Applications of data mining.

### Module V: [8L]

#### Clustering

Introduction, Issues in clustering, Types of clustering: Hierarchical and partitioning clustering, K-means clustering applications of clustering.

#### Classification:

Introduction, Applications of clustering, Classification technique: Decision trees.

## Text Books:

1. "Data Mining Techniques", K. Pujari, Universities Press, 2013.
2. "Database Concepts", H. F. Korth, A. Silberchatz, Tata McGraw Hill, 2010.

## Reference Books:

1. "Data Mining", V. Pudi and P. R. Krishna ,Oxford University Press India, 2009.
2. "Database Systems: A Practical Approach to Design, Implementation and Management", B. Connolly, Pearson Education, 2007.

**Text Books:**

1. "Discrete Mathematics", K. D. Joshi, Wiley Eastern Ltd.

**Reference Books:**

1. "Applied Algebra for Computer Science", Arthur Gill, Prentice Hall.
2. "A Text Book of Graph Theory", R. Balakrishnan and K.Ranganathan, Springer.
3. "Discrete Mathematical Structures", D. S. Chandrasekharaih, Prism Books, 2005.

**Design and Analysis of Algorithm****Code: CSEM103****Credit: 4****Contacts: 4L****Allotted Lecture: 40L****Module I: [8L]**

Time and Space Complexity. Asymptotic Notations. Recurrence For Divide And Conquer And Its Solution, The Substitution Method And Recursion-Tree Method For Solving Recurrences. The Master Method: Proof And Solving Recurrence Problems, Merge Sort, Heap Sort, Quick Sort And Their Complexity Analysis.

**Module II: [8L]**

Advanced Data Structure: Adt and Data Structure, Linear Vs Non-Linear Data Structure. Tree: Tree As An Adt, Definition And Terminologies, Threaded Binary Tree, Bst. Avl Tree, Balance Multi Way Search Tree: 2-3 Tree, Red- Black Tree, B Tree, B+ Tree, Tries, Spatial Data Representation Using K-D Tree, Quad Tree

**Module III: [12L]**

Graph: Definition, Computer Representation Of Graphs, Graph Traversals: Bfs & Dfs, Spanning Tree. Graph Colouring-Chromatic Number, Algorithm For Transitive Closure, Topological Sort, and Critical Paths.

Dynamic Programming: Matrix-Chain Multiplication, All Pair Shortest Paths, Single Source Shortest Path, Travelling Salesman Problem, 0-1 Knapsack Problem, Lcs Problem.

Greedy Method : Knapsack Problem, Job Sequencing With Deadlines, Activity – Selection, Huffman Codes, Minimum Spanning Tree By Prim's And Kruskal's Algorithms.

Disjoint Set Manipulation: Set Manipulation Algorithm Like Union-Find, Union By Rank, Path Compression. Topological Sorting.

Backtracking: Use in Solving Problem, 4 Queen And 8-Queen Problem, Subset Sum Problem

Branch and Bound: Basic Method, Applications: The 15-Puzzle Problem,

**Module IV: [4L]**

Computational Geometry: Robust Geometric Primitives, Convex Hull, Triangulation, Voronoi Diagrams, Nearest Neighbor Search, Range Search, Point Location, Intersection Detection, Bin Packing, and Medial-Axis Transform.

**Module V: [8L]**

Set and String Problems: Set Cover, Set Packing, String Matching, Approximate String Matching, Text Compression, Cryptography, Finite State Machine Minimization, Longest Common Substring/Subsequence, Shortest Common Superstring. Advanced Areas: Notion Of Np-Completeness: P Class, Np-Hard Class, Np-Complete Class, and Circuit Satisfiability Problem. Approximation Algorithm.

**Text Books:**

1. "The Design And Analysis Of Algorithms", A.Aho, J.Hopcroft And J.Ullman, Pe.
2. "Introduction To Algorithms", T Cormen, C Leiserson And R Rivest, Phi.

appropriate method Data Processing Operations, Elements of Analysis, Statistics in Research, Measures of Dispersion, Measures of Skewness, Regression Analysis, Correlation.

**Module V: [4L]**

Techniques of Hypotheses, Parametric or Standard Tests Basic concepts, Tests for Hypotheses I and II, Important parameters limitations of the tests of Hypotheses, Chi-square Test, Comparing Variance, As a non-parametric Test, Conversion of Chi to Phi, Caution in using Chi-square test.

**Module VI: [4L]**

Analysis of Variance and Co-variance ANOVA, One way ANOVA, Two Way ANOVA, ANOCOVA Assumptions in ANOCOVA, Multivariate Analysis is Technique Classification of Multivariate Analysis, factor Analysis, R-type Q Type factor Analysis, Path Analysis

**Text Books:**

1. "Teaching Methodology", Caroline W. Ndirangu, African Virtual University.
2. "Research Methodology", C.R. Kothari, Wiley Eastern.

**Reference Books:**

1. "Formulation of Hypothesis", Willkinson K.P, L Bhandarkar, Hymalaya Publication, Bombay.
2. "Research in Education", John W Best and V. Kahn, PHI Publication.
3. "Research Methodology- A step by step guide for beginners", Ranjit Kumar, Pearson Education.
4. "Management Research Methodology-Integration of principles, methods and Techniques", K.N. Krishna swami and others, Pearson Education.

**Discrete Structure**

**Code: CSEM102**

**Credit: 4**

**Contacts: 4L**

**Allotted Lecture: 40L**

**Module I: [10L]**

Set Theory - Set operations, properties - power set - methods of proof - relations, graph and matrix of a relation - partial and total orders, well ordering - equivalence relations, classes and properties - functions, 1-1, onto and bijective.

**Module II: [6L]**

Induction and Combinatorics - Peano's axioms - Mathematical induction (simple and strong) - pigeon-hole principle - principle of inclusion and exclusion.

**Module III: [10L]**

Algebraic Structures - Semi-groups, monoids, groups, subgroups and their properties – cyclic groups - cosets - permutation groups - Lagrange's theorem - Cayley's theorem – normal subgroups - homomorphism of groups - quotient groups - rings and fields.

**Module IV: [6L]**

Recurrence Relations and Generating Functions - Homogeneous and inhomogeneous recurrences- solving recurrences - Repertoire method - Perturbation method - Convolutions - simple manipulations and tricks.

**Module V: [8L]**

Graph Theory - Representation of a graph - Trees - Cycles - Paths and connectedness – Graph Isomorphism - Operations on graphs - Vertex and edge cuts.



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|    |                      |    |                  |
|----|----------------------|----|------------------|
| ES | Engineering Sciences | OE | Open Electives   |
|    |                      | MC | Mandatory Course |

## Semester – 1

### Teaching & Research Methodology

Code: CSEM101

Credit: 4

Contacts: 4L

Allotted Lecture: 40L

#### Teaching Methodology

##### Module I: [4L]

Introduction to content, Elements of instruction, Learning objectives, Roles of the teacher and the learner in instruction.

##### Module II: [4L]

Application of theories of learning to teaching and learning, Sequence of learning and Strategies of learning, Teaching methods, their merits and demerits, Use of ICT in teaching & learning, Classroom management, Individual differences.

##### Module III: [4L]

Understanding the syllabus, Preparation of a scheme of work, Lesson plan preparation, Micro teaching.

##### Module IV: [4L]

Define measurement, assessment, test, evaluation, Purpose of assessment and evaluation, Types of tests, Grading and reporting the results assessment, Evaluating teaching and learning.

#### Research Methodology

##### Module I: [4L]

Research methodology: An Introduction Objectives of Research, Types of Research, Research Methods and Methodology, Defining a Research Problem, Techniques involved in defining a Problem.

##### Module II: [4L]

Research Design Need for Research Design, Features of Good Design, Different Research Designs, Basic Principles of Experimental Designs, Sampling Design, Steps in Sampling Design, Types of Sampling Design, Sampling Fundamentals, Estimation, Sample size Determination, Random sampling.

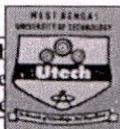
##### Module III: [4L]

Measurement and Scaling Techniques Measurement in Research, Measurement Scales, Sources in Error, Techniques of Developing Measurement Tools, Scaling, Meaning of Scale, Scale Construction Techniques.

##### Module IV: [4L]

Methods of Data Collection and Analysis Collection of Primary and Secondary Data, Selection of

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#### Functions (3L):

What is function? Calling functions, Defining Functions. Variable Scope, more about arguments. Working with Arrays and Some Array-Related Functions.

#### Working with Objects (2L):

Creating Objects, Object Instance Working with Strings, Dates and Time: Formatting strings with PHP, Investigating Strings with PHP, Manipulating Strings with PHP, Using Date and Time Functions in PHP.

#### Working with Forms (2L):

Creating Forms, Accessing Form Input with User defined Arrays, Combining HTML and PHP code on a single Page, Using Hidden Fields to save state, Redirecting the user, Sending Mail on Form Submission, and Working with File Uploads.

#### Learning basic SQL Commands (2L):

Learning the MySQL Data types, Learning the Table Creation Syntax, Using Insert Command, Using SELECT Command, Using WHERE in your Queries, Selecting from Multiple Tables, Using the UPDATE command to modify records, Using the DELETE Command, Frequently used string functions in MySQL, Using Date and Time Functions in MySQL.

#### Interacting with MySQL using PHP (2L):

MySQL Versus MySQLi Functions, Connecting to MySQL with PHP, Working with MySQL Data.

### **Module IV-6L(Multimedia for WEB)**

#### Multimedia Application Development (4L):

Pixel, Image Resolution, Image Editing using Photoshop, 2D & 3D Animation, Logo Design, Banner. Animated Component Preparation using Flash & Action script.

#### Multimedia Web Applications (2L):

Multimedia over IP: RTP, RTCP. Streaming media, Codec and Plugins, VoIP, Text and Voice Chat.

#### Books:

1. Internetworking Technologies, An Engineering Perspective, Rahul Banerjee, PHI Learning, Delhi, 2011.
2. Web Technology & Design, C.Xavier, New Age International Publication, Delhi
3. Web Technology: A Developer's Perspective, N.P. Gopalan and J. Akilandeswari, PHI Learning, Delhi, 2013.
4. Sams Teach Yourself PHP in 24 Hours, Third Edition
5. Wrox, Beginning PHP, Apache, MySQL Web Development
6. Wrox, Beginning PHP
7. ULLMAN, LARRY, 'PHP AND MYSQL FOR DYNAMIC WEB SITES'
8. ULLMAN, LARRY, 'PHP ADVANCED FOR THE WORLD WIDE WEB'

### **Soft Computing: PGCSE 204(D)**

[40 LECTURES]

Introduction to Soft Computing [8L]

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Evolution of Computing - Soft Computing Constituents – From Conventional Artificial Intelligence to Computational Intelligence - Machine Learning Basics.

#### **Fuzzy Logic [8L]**

Fuzzy sets and Fuzzy logic: Introduction, Fuzzy sets versus crisp sets, operations on fuzzy sets, Extension principle, Fuzzy relations and relation equations, Fuzzy numbers, Linguistic variables, Fuzzy logic, Linguistic hedges, Applications, fuzzy controllers, fuzzy pattern recognition, fuzzy image processing, fuzzy database.

#### **Artificial Neural Networks [8L]**

Artificial Neural Network: Introduction, basic models, Hebb's learning, Adaline, Perceptron, Multilayer feed forward network, Back propagation, Different issues regarding convergence of Multilayer Perceptron, Competitive learning, Self-Organizing Feature Maps, Adaptive Resonance Theory, Associative Memories, Applications.

#### **Genetic Algorithms [8L]**

Evolutionary and Stochastic techniques: Genetic Algorithm (GA), different operators of Genetic Algorithm, Analysis of selection operations, Hypothesis of building blocks, Schema theorem and convergence of Genetic Algorithm, Simulated annealing and Stochastic models, Boltzmann Machine, Applications. Rough Set: Introduction, Imprecise Categories Approximations and Rough Sets, Reduction of Knowledge, Decision Tables, and Applications.

#### **Hybrid Systems [8L]**

Neural-Network-Based Fuzzy Systems, Fuzzy Logic-Based Neural Networks, Genetic Algorithm for Neural Network Design and Learning, Fuzzy Logic and Genetic Algorithm for Optimization, Applications.

#### **Books/References:**

1. Mitchell Melanie, "An Introduction to Genetic Algorithm", Prentice Hall, 1998.
2. David E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison Wesley, 1997.
3. S. Haykin, "Neural Networks", Pearson Education, 2ed, 2001.
4. S. Rajasekaran & G. A. V. Pai, Neural Networks, Fuzzy logic, and Genetic Algorithms, PHI.
5. Fuzzy Sets and Fuzzy Logic, Klir & Yuan, PHI, 1997
6. Rough Sets, Z. Pawlak, Kluwer Academic Publisher, 1991.
7. Neural Networks, Fuzzy logic, and Genetic Algorithms, S. Rajasekaran and G. A. V. Pai, PHI.
8. Intelligent Hybrid Systems, D. Ruan, Kluwer Academic Publisher, 1997.

#### **PGCSE204E**

#### **Cryptography and Computer Security**

Total Lectures: 34

#### **Introduction (4L)**

Linear algebra: non linearity, echelon form of matrix, Galois Field, vector space, Modular arithmetic

#### **Coding Theory [4L]**

- Elementary Concepts of Coding Theory;
- Applications of Algebraic Coding Theory to Cryptography
- Huffman coding
- Hamming coding

#### **Primality Testing [3L]**

- Primality Testing

  
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information processing and group connectivity, Target tracking, localization and identity management, Power management, Security and privacy.

#### **Topology Control and Clustering in Adhoc Networks [5L]**

Algorithms for Graphs Modeling Wireless Ad Hoc Networks, Clustering and Network Backbone, Dominating-Set-Based Routing in Ad Hoc Wireless Networks, Formation of a Connected Dominating Set, Backbone-Formation Heuristics.

#### **Mobile, Distributed and Pervasive Computing [5L]**

Pervasive Computing Applications, Architecture of Pervasive Computing Software, Indoor Wireless Environments, Challenges for the Future: Nomadic Computing.

#### **Text Books:**

- a) Sivaram Murthy, Manoj, "Adhoc Wireless and Sensor Networks: Architecture and Protocols", Pearson.
- b) Vijay Garg, "Wireless Communications and Networking", Morgan Kaufmann Publishers
- c) Gast, "802.11 Wireless Networks", Oreilly-SPD
- d) Theodore Rappaport, "Wireless Communications: Principles and Practice" TMH.
- e) J. Schiller, Pearson Education, "Mobile Communications", TMH.
- f) William C.Y Lee Cellular Mobile Telecommunications, TMH
- g) Garg and Wilkes, Principles and Applications of GSM, Pearson.

#### **Reference Books**

- a) Gabrilovska, Prasad, "Adhoc Networking Towards Seamless Communication", Springer.
- b) Azzedine Boukerche, "Handbook of Algorithms for Wireless Networking and Mobile Computing", Chapman and Hall/CRC, New York.
- c) Wagner, Wattenhofer (Eds.), "Algorithms for Adhoc and Sensor Networks: Advanced Lectures", Springer Lecture Notes in Computer Science.
- d) Mukherjee, Bandopadhyay, Saha, "Location Management and Routing in Mobile Wireless Networks", Artech House, London.
- e) Redl, S.M., Weber, M.K., Oliphant, M.W.: An Introduction to GSM. Artech House, London.
- f) Mehrotra, A.: GSM System Engineering. Artech House, London.
- g) Ivan Stojmenovic, "Handbook of Wireless Networking and Mobile Computing", Wiley Inc, New York.
- h) XiangYang Li, "Wireless Adhoc and Sensor Networks", Cambridge University Press.

### **ADVANCED WEB TECHNOLOGY**

**PGCSE204C**

**Contracts: 4L**

**Credits- 4**

**Total 40 lectures**

#### **Module I-6L (Internet & WWW)**

**Introduction (2L):**

  
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