

## DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

## DETAILED SYLLABI OF COURSES

Sub. Code	Subjects	L-T-P	Credits
CS 610	Software Design	3-0-0	3
CS 611	Foundations of E - Commerce	3-0-0	3
CS 612	Software Engineering	3-0-0	3
CS 613	Combinatorial Optimization	3-0-0	3
CS 614	Software Project, Process and Quality Management	3-0-0	3
CS 615	Software Testing	3-0-0	3
CS 616	Algorithm Design	3-0-0	3
CS 617	Graph Theory and Network Algorithms	3-0-0	3
CS 618	Real Time Systems Design	3-0-0	3
CS 619	Software Engineering Requirements and Modeling	3-0-0	3
CS 620	Software Testing	3-0-0	3
CS 621	Cryptographic Foundations	3-0-0	3
CS 622	Design of Computer Networks	3-0-0	3
CS 623	Ad-hoc and Wireless Networks	3-0-0	3
CS 624	Database Engineering	3-0-0	3
CS 625	Data Mining and Data Warehousing	3-0-0	3
CS 626	Intrusion Detection Systems	3-0-0	3
CS 627	Wireless Network Security	3-0-0	3
CS 628	Wireless Sensor Networks	3-0-0	3
CS 629	Network Security	3-0-0	3
CS 630	Artificial Intelligence	3-0-0	3
CS 631	Information Theory and Coding	3-0-0	3
CS 632	Distributed Operating Systems	3-0-0	3
CS 633	Game Theory	3-0-0	3
CS 634	Bioinformatics	3-0-0	3
CS 635	Biometric Security	3-0-0	3
CS 636	Image Processing	3-0-0	3
CS 637	Digital Signal Processing	3-0-0	3
CS 638	Pattern Recognition	3-0-0	3
CS 639	Soft Computing	3-0-0	3
CS 640	Requirements Engineering	3-0-0	3
CS 641	Advanced Computer Architecture	3-0-0	3
CS 642	Cluster and Grid Computing	3-0-0	3
CS 643	Embedded Systems	3-0-0	3
CS 644	Fault Tolerant Computing	3-0-0	3
CS 645	Parallel Algorithms	3-0-0	3
CS 646	Parallel and Distributed Computing	3-0-0	3
CS 647	Performance Evaluation of Computer Systems	3-0-0	3

CS 648	Security and Fault Tolerance in Distributed System	3-0-0	3
CS 649	VLSI System Design	3-0-0	3
CS 650	Software Metrics	3-0-0	3
CS 651	Software Reliability	3-0-0	3
CS 652	Software Architecture	3-0-0	3
CS 653	Software Processes	3-0-0	3
CS 654	Software Agent	3-0-0	3
CS 655	Software Design Pattern	3-0-0	3
CS 656	Software Configuration Management	3-0-0	3
CS 657	Principles of Management	3-0-0	3
CS 658	Web Technologies	3-0-0	3
CS 659	Service Oriented Architecture	3-0-0	3
CS 660	Knowledge Management	3-0-0	3
CS 670	Data Mining Lab (Programming Laboratory - I)	0-0-3	2
CS 671	Programming Laboratory - II	0-0-3	2
CS 672	Software Engineering Laboratory	0-0-3	2
CS 673	Image Processing Laboratory	0-0-3	2
CS 674	Network Simulation Laboratory	0-0-3	2
CS 675	Soft Computing Laboratory	0-0-3	2
CS 676	Cryptography Laboratory - I	0-0-3	2
CS 677	Software Laboratory using NS2/NETSIM/QUALNET	0-0-3	2
CS 678	OS and Database Security Laboratory	0-0-3	2
CS 679	Network Security Lab	0-0-3	2
CS 680	Cryptography Laboratory - II	0-0-3	2
CS 681	Special Topic in Computer Science and Engineering - I	3-0-0	3
CS 682	Special Topic in Computer Science and Engineering - II	3-0-0	3
CS 683	Special Laboratory in Computer Science and Engineering - I	0-0-3	2
CS 684	Special Laboratory in Computer Science and Engineering - II	0-0-3	2
CS 685	Seminar & Technical Writing - I	0-0-3	2
CS 686	Seminar & Technical Writing - II	0-0-3	2
CS 687	Seminar & Technical Writing - III	0-0-3	2
CS 688	Seminar & Technical Writing - IV	0-0-3	2
CS 689	Artificial Intelligence Laboratory	0-0-3	2
CS 690	Research Practice	0-0-0	2
CS 691	Summer Research/Industrial Project	0-0-6	4
CS 692	Comprehensive Viva-Voce	0-0-0	4
CS 693	Research Project - I	0-0-0	20
CS 694	Research Project - II	0-0-0	20
CS 697	Software Laboratory using MATLAB	0-0-3	2
CS 698	Software Laboratory using VHDL/VERILOG	0-0-3	2
CS 699	Software Laboratory using ORACLE	0-0-3	2
CS 789	Product Development Laboratory	0-0-3	2

CS 611	FOUNDATION OF E- COMMERCE	3 Credits [3-0-0]
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Introduction to Business/Network Concepts, Technology and business integration. The Hardware of E commerce: Introduction to networks, Introduction to the, business server, Electronic Business Structure: Protocols, The WebPages, Portals of Business, Web salesmanship, Introduction to the client machine and OS. Business servers: Mail, Applications, Proxy, Entertainment, ISP, Banking. Advertising on the Network: Web software infrastructure, personalization and tracking, Web Billboards, The 'Hit' Theory, Intellectual property for sale, 'Bots'. Business Netiquette: Dos and Don't of WebPages, Client service, Personnel, Technical support, Network services, Accounting and statistics, integration of catalogs and other trading information. Business Security: The Credit card on the Net, Secure transmission, Internal security of telephony, E mail security, auctions and trading mechanisms, safe exchange, payment mechanisms and protocols, searching hyperlink structures, data mining, copy right protection and security. Special topics in E-Commerce.

**Essential Readings:**

1. W. Hanson, Principles of Internet Marketing, South Western Publishing, 2004.
2. K. K. Bajaj & D. Nag, E Commerce, Tata McGraw Hill, 2006.

**Supplementary Readings:**

1. R. Kalakola and A. B. Whiston, Frontiers of Electronic Commerce, Addison-Wesley, 1996.
2. Greensein, Feinman, Electronic Commerce Security, Risk management and Control, Tata McGraw Hill, 2000.
3. Green Stein, Electronic Commerce, Tata McGraw Hill, 2007.

CS 612	SOFTWARE ENGINEERING	3 Credits [3-0-0]
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Software Life Cycle Models, Managing software projects, Project management concepts, Software process and Project metrics, Software Project Planning, Risk Analysis and Management, Project scheduling and tracking, Software Quality Assurance, Software Configuration Management. Conventional methods for software engineering, System Engineering, Requirements Analysis and Specifications, Analysis Modeling, Design Concepts and principles, Architectural design, User Interface Design, Component level Design, Software Testing Techniques, Software testing Strategies, Software Reliability, Technical metrics for software, CASE tools, Software Maintenance, Software Reusability. Object Oriented software engineering: Object Oriented Concepts and principles, Object Oriented analysis, Object Oriented Design, and Object Oriented testing, Technical metrics for Object Oriented Systems. Special topics in Software Engineering.

**Essential Readings:**

1. R. S. Pressman, Software Engineering A Practitioner's Approach, McGraw Hill Publications, 2006.
2. R. Mall, Fundamentals of Software Engineering, Prentice Hall of India, 2nd Ed, 2006.

**Supplementary Readings:**

1. I Sommerville, Software Engineering, Pearson Education, Asia, 2006.
2. P. Jalote, An Integrated Approach to Software Engineering, Narosa, 3rd reprint, 2006.
3. A. Behferooz & F. J. Hudson, Software Engineering Fundamentals, Oxford Univ. Press, 2000.
4. Baude, Object Oriented Software Engineering, Wiley, 2006.

CS 613	COMBINATORIAL OPTIMIZATION	3 Credits [3-0-0]
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Optimization Problem: Global and Local optima; Convex sets and functions; Convex programming problem; Simplex algorithm: Forms of linear programming problem; Geometry of linear program; Duality: Dual of a linear program in general form; shortest path problem and its dual; Dual simplex algorithm; Primal dual algorithm: Shortest path problem, max flow; Algorithms and complexity: Computability; time bound; analysis of algorithm;

polynomial time algorithm; Algorithm for matching; weighted matching. Special topics in Combinatorial Optimization

**Essential Reading:**

1. C. H. Papadimitriou, K. Steiglitz, Combinatorial optimization: algorithm and Complexity, Prentice Hall of India, 2006.
2. D. Knuth, Art of Computer Programming, Vol. IV, Addison Wesley, 1st ed. 2008.

**Supplementary Reading:**

1. C. H. Papadimitriou, Computational Complexity, Addison Wesley, 1st ed. 2002.

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CS 614	SOFTWARE PROJECT, PROCESS AND QUALITY MANAGEMENT	3 Credits [3-0-0]
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Introduction to S/W project management, S/W project management competencies, responsibilities of a software project manager, Software process, S/W process models, project planning, organization of project team, S/W size estimation, estimation of effort & duration, Halstead's software Science, models, dependency & scheduling, staffing, Organizing a software engineering project, S/W configuration management, monitoring & controlling S/W projects, developing requirements, risk management, project tracking & control, communication & negotiating, S/W quality, S/W quality engineering, defining quality requirements, quality standards, practices & conventions, ISO 9000, ISO 9001, S/W quality matrices, managerial and organization issues, defect prevention, reviews & audits, SEI capability maturity model, PSP, six sigma. Special topics in process and quality management.

**Essential Reading:**

1. B. Hughes, M. Cotterell, Software Project Management, McGraw Hill, 4th ed, 2005.
2. R. Walker, Software Project Management, Pearson, 2003.

**Supplementary Reading:**

1. R. H. Thayer, Software Engineering Project management, IEEE CS Press, 2nd Ed, 1988.
2. R. Pressman, Software Engineering A Practitioner's approach, McGraw Hill, 4th Ed, 2005.

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CS 615	SOFTWARE TESTING	3 Credits [3-0-0]
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Introduction, Basic concepts, discrete mathematics for testers, Graph theory for testers, Black box testing: Boundary value testing, Equivalence class testing, White box testing: statement coverage, Branch coverage, condition coverage, path coverage, McCabe's cyclomatic complexity; Decision Table based testing, Data flow based testing, Integration testing, System testing, Interaction testing, Performance testing, Mutation testing, Regression testing, error seeding, object oriented testing: issues in object oriented testing, Test case design by object oriented software, Fault based testing, test cases and class hierarchy, Scenario based Test design, Testing surface structure and deep structure, Class testing: Random testing for object oriented classes, Partition testing at the class level; Inter class test case design: multiple class testing, tests derived from behavior models, Test case generation using UML diagrams, GUI testing, object oriented system testing. Special topics in software testing.

**Essential Reading:**

1. C. J. Paul, Software testing: A craftsmen's approach, CRC Press, 2nd Ed, 2002.
2. R. Gopalswamy, Software testing, Pearson, 2005.

**Supplementary Reading:**

1. G. J. Myers, The art of software testing, Wiley Interscience New York, 2005.
2. R. S. Pressman, Software Engineering A Practitioner's approach, McGraw Hill, 4th Ed, 1982.
3. R. Mall, Fundamentals of Software Engineering, Prentice Hall of India, 2nd Ed, 2003.

CS 616

ALGORITHM DESIGN

3 Credits [3-0-0]

Measuring Algorithm Efficiency: Implementation independent measurement of algorithm efficiency, time and space resources, growth in terms of input size, polynomial vs. exponential growth algorithms, worst and average case efficiency, big Oh notation, algorithm efficiency vs. inherent problem (any algorithm) complexity, deterministic and non deterministic algorithms, algorithm analysis techniques, amortization, standards and implementation dependent resource measurement. Algorithm Design Paradigms: Characterization of algorithm design paradigms, Utilization of design paradigms for problems across application areas of sorting, selection, computer arithmetic and algebraic computation, graphs and networks, computational geometry. Computation Models and Complexity: NP Complete Problems, NP hard problems, Proving of problem to NP Complete, different NP complete problem. Approximation Algorithms, Randomized Algorithms: Some Complexity Classes, Computing  $\pi$ , Numerical Integration, Primality Testing, Randomize Algorithm for Majority Element, Graph Algorithms, Lower Bound Techniques, Nature Inspired Algorithms: Genetic algorithm; Ant Colony Optimization, DNA algorithms, Parallel Algorithms: Memory Multiprocessor. Special topics in algorithms design.

**Essential Reading:**

1. S. K. Bose, Design Methods and Analysis of algorithms, Prentice Hall of India, 2005.
2. A. Levitin, Introduction to the design & analysis of Algorithms, Pearson, 2003.

**Supplementary Reading:**

1. M. A. Weiss, Data Structures and Algorithm Analysis in Java, Pearson, 2003.
2. T. H. Cormen, C. E. Leiserson, and Ronald L. Rivest, Introduction to Algorithms, Prentice Hall of India, 2005.
3. Baase and Gelder, Computer Algorithms, Introduction to design & Analysis, Pearson, 2000.

CS 617

GRAPH THEORY AND NETWORK ALGORITHMS

3 Credits [3-0-0]

Introduction: Graphs, Isomorphism, Walks, Paths, Circuits, Trees, Properties of Trees, Cotrees and Fundamental Circuits, Cut Sets, Fundamental Cut Sets and Cut Vertices, Planar and Dual Graphs, Metric Representation of Graphs, Coloring and covering and partitioning of a graph, chromatic number, chromatic partitioning, chromatic polynomials, matching, covering, four color problem, Directed graphs, some type of directed graphs, Directed paths, and connectedness, Euler digraphs, trees with directed edges, fundamental circuits in digraph, matrices A, B and C of digraphs adjacency matrix of a digraph,, enumeration, types of enumeration, counting of labeled and unlabeled trees, polya's theorem, graph enumeration with polya's theorem; Graph Algorithms: Elementary Graph Algorithms, Representations of graphs, Breadth-first search, Depth-first search, Topological sort, strongly connected components; Minimum Spanning Trees: Growing a minimum spanning tree, The algorithms of Kruskal and Prim, Single-Source Shortest Paths: Shortest paths and relaxation, Dijkstra's algorithm, The Bellman-Ford algorithm, Single-source shortest paths in directed acyclic graphs, Difference constraints and shortest paths, All-Pairs Shortest Paths: Shortest paths and matrix multiplication, The Floyd-Warshall algorithm, Johnson's algorithm for sparse graphs, and A general framework for solving path problems in directed graphs; Maximum Flow: Flow networks, The Ford-Fulkerson method, Maximum bipartite matching, Preflow-push algorithms, The lift-to-front algorithm. Special topics in graph theory and network algorithms.

**Essential Reading:**

1. T. H. Cormen, C. E. Leiserson and R. L. Rivest, Introduction to Algorithms, Prentice Hall of India, 3rd ed, 2006.
2. N. Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 2004.

**Supplementary Reading:**

1. D. B. West, Introduction to Graph Theory, 2nd Ed, Prentice Hall of India, 2007.
2. R. Diestel, Advanced Graph Theory, Springer Verlag Heidelberg, New York, 2005.
3. M. T. Goodrich and R. Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Wiley, 1st ed, 2001.

CS 618

REAL TIME SYSTEMS DESIGN

3 Credits [3-0-0]

Introduction to Real Time systems, applications of Real Time systems, basic model of Real Time systems, characteristics of Real Time systems, types of Real Time systems: hard, firm, soft, timing constraints, modeling timing constraints, Real Time task scheduling: basic concepts, clock driven scheduling, table driven scheduling, cyclic, schedulers, hybrid schedulers, event driven scheduling, EDF Scheduling, RMA, DMA, resource sharing among RT tasks, Priority inversion, Priority Inheritance Protocol, Highest Locker Protocol, Priority Ceiling Protocol, Scheduling Real Time tasks in multiprocessor and distributed systems, Fault tolerant scheduling of tasks, clocks in distributed Real Time systems, Commercial Real Time Operating Systems, timers, UNIX and Windows as RT OS, POSIX, PSOS, VRTX, QNX, RT Linux, Lynx, other RT OS, benchmarking RT OS, RT communications, QoS framework, models, Real Time Communication in a LAN, IEEE 802.4, RETHER, Communication over Packet Switched Networks, Routing algorithms, RSVP, rate control, RT databases, Applications, characteristics of temporal data, Concurrency control, Commercial RT databases. Special topics in real time systems.

**Essential Reading:**

1. J. W. S. Liu, Real time Systems, Pearson Education, 6th impression, 2008.
2. R. Mall, Real Time Systems, Pearson, 2007.

**Supplementary Reading:**

1. C. M. Krishna and K. G. Shin, Real Time Systems, McGraw Hill, reprinted 2004.
2. P. A. Laplante, Real Time Systems Design & Analysis, Wiley, 3rd Ed, 2004.

CS 621

CRYPTOGRAPHIC FOUNDATIONS

3 Credits [3-0-0]

Introduction to cryptography: Attacks, Services, and Mechanisms, Security Attacks, Security Services, A Model for Inter network Security. Conventional Encryption: Classical and Modern Techniques, Conventional Encryption: Algorithms Triple DES, International Data Encryption Algorithm, Blowfish, RC5, CAST, RC2, Characteristics of Advanced Symmetric Block Ciphers. Confidentiality Using Conventional Encryption: Placement of Encryption Function, Traffic Confidentiality, Key Distribution, Random Number Generation.; Public Key Cryptography Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Diffie Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication and Hash Functions: Authentication Requirements, Authentication Functions, Message Authentication Codes, Hash Functions, Security of Hash Functions and MACs. Hash and Mac Algorithms (MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA I), RIPEMD, HMAC), Digital Signatures and Authentication Protocols and Web Security. Special topics in cryptographic foundations.

**Essential Reading:**

1. R. E. Smith, Internet Cryptography, AWL.
2. A. J. Menezes, Handbook of Applied Cryptography, CRC Press.

**Supplementary Reading:**

1. J. Hershey, Cryptography Demystified, McGraw Hill.
2. J. Knudsen, Java Cryptography, O'Reilly.

CS 622

DESIGN OF COMPUTER NETWORKS

3 Credits [3-0-0]

Introduction to computer networks; telephone networks, networking principles; multiple access, multiplexing FDM, TDM, SM; local area networks Ethernet, token ring, FDDI; switching circuit switching, packet switching, multicasting; scheduling performance bounds, best effort disciplines, naming and addressing, protocol stack, SONET/SDH; ATM networks AAL, virtual circuits, SSCOP; Internet addressing, routing, end point control;

Internet protocols IP, TCP, UDP, ICMP, HTTP; traffic management models, classes, scheduling; control of networks QoS, static and dynamic routing, Markov chains, queuing models, Bellman Ford and Dijkstra's algorithms, window and rate congestion control, large deviations of a queue and network, open and closed loop flow control, control of ATM networks. Mobile IP, Voice over IP (VoIP), VPNs, Network Security. Congestion Control: Control vs. Avoidance, Overview of Algorithms, Congestion in the Internet. Management: Quality of Service (QoS), network vs. distributed systems management, Protocols, web based management. Special topics in design of computer networks.

**Essential Reading:**

1. J. Walrand and P. Varaya, High Performance Communication Networks, Harcourt Asia (Morgan Kaufmann), 2000.
2. S. Keshav, An Engineering Approach to Computer Networking, Pearson Education, 2004

**Supplementary Reading:**

1. L. Garcia and I. Widjaja, Communication Networks: Fundamental Concepts and Key Architectures, Tata McGraw Hill, 2000.
2. J. F. Kurose and K. W. Ross, Computer Networking: A Top Down Approach Featuring the Internet, Pearson Education, 2001.

CS 623	AD-HOC AND WIRELESS NETWORKS	3 Credits [3-0-0]
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Ad Hoc Wireless Networks: Issues in Ad Hoc Wireless Networks, Ad Hoc Wireless Internet; MAC Protocols for Ad Hoc Wireless Networks: Issues in Designing a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols; Routing Protocols for Ad Hoc Wireless Networks: Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Power Aware Routing Protocols; Multicast routing in Ad Hoc Wireless Networks: Issues in Designing a Multicast Routing Protocol, Classifications of Multicast Routing Protocols, Energy Efficient Multicasting, Multicasting with Quality of Service Guarantees, Application Dependent Multicast Routing; Security Protocols for Ad Hoc Wireless Networks: Security in Ad Hoc Wireless Networks. Network Security Requirements. Issues and Challenges in Security Provisioning. Network Security Attacks. Key Management. Secure Routing in Ad Hoc Wireless Networks; Energy Management in Ad Hoc Wireless Networks: Classification of Energy Management Schemes, Transmission Power Management Schemes, System Power Management Schemes. Special topics in Ad-hoc and wireless networks.

**Essential Reading:**

1. C S. Ram Murthy, B. S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall of India, 2nd ed. 2005.
2. R. Hekmat, Ad hoc Networks: Fundamental Properties and Network Topologies, Springer, 1st ed. 2006.

**Supplementary Reading:**

1. B. Tavli and W. Heinzelman, Mobile Ad Hoc Networks: Energy Efficient Real Time Data Communications, Springer, 1st ed. 2006.
2. G. Anastasi, E. Ancillotti, R. Bernasconi, and E. S. Biagioni, Multi Hop Ad Hoc Networks from Theory to Reality, Nova Science Publishers, 2008

CS 624	DATABASE ENGINEERING	3 Credits [3-0-0]
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Introduction to Database systems: Data Independence, Data Models, levels of abstraction, structure of DBMS, Relational Model, Integrity constraints, Relational Languages, Query Languages: SQL, QUEL, QBE, Aggregate operators, Embedded and Dynamic SQL. File Organization: Storage, Buffer management, Record and page formats, File organization techniques, Indexing. Query optimization: Query processing on various operations, Translating SQL queries, estimating the cost. Database design: E R Model, Functional dependencies, normalization, multi valued dependencies. Concurrency control and recovery: transaction, schedules, Lock



based concurrency, Lock management, Concurrency control without locking, Crash recovery log, check pointing, media recoveries. Database Security, Distributed databases design, Object Oriented database design & its implementation, Introduction to recent advances in database technology. Special topics in database engineering.

**Essential Reading:**

1. J. D. Ullman, Principles of Data Base Systems, Galgotia Publisher, New Delhi, 2nd Ed, 2003.
2. Silberschatz, H. F. Korth & A. Sudarshan, Database system Concepts, McGraw Hill,

**Supplementary Reading:**

1. B. Desai, An Introduction to database system, Galgotia, 1997.
2. C. J. Date: An introduction to Data Base Systems, Addison Wesley, 1995.
3. R. Elmasri, S. Navathe, S. B. Navathe, R. Sunderraman, Fundamentals of Database Systems, Addison Wesley, 2nd ed, 2005.
4. R. R. Krishnan, Database Management Systems, McGraw Hill, reprint 2007

CS 625	DATA MINING & DATA WAREHOUSING	3 Credits [3-0-0]
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Introduction to Data mining: Motivation for Data Mining, its importance, Role Data in Data Mining, Data Mining functionalities, patterns in data mining, Type of patterns, Classification of Data Mining Systems, Major issues in Data Mining; Data Warehousing and OLTP technology for Data Mining, Data Mining Languages, and System Architectures, Concept Description: Characterization and Comparison, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis, Mining Complex Data, Applications and Trends in Data Mining Characteristics of data warehouse, Data Mart, Online Analytical Processing, OLAP tools, Data warehouse Architecture, Organizational Issuer, Tools for Data warehousing, Performance consideration, case studies. Special topics in data mining and data ware housing.

**Essential Reading:**

1. J. Han & M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2nd Ed, 2006.
2. M. J. A. Berry and G. Linoff, Mastering Data Mining: The Art and Science of Customer Relationship Management, Wiley Computer Publishing, 2000.

**Supplementary Reading:**

1. P. Adriaans & D. Zantinge, Data Mining, Addison Wesley, 1996.
2. R. Mattison, Data Warehousing: Strategies, Tools and Techniques, McGraw Hill, 1996.
3. P. Ponniah, Data Warehousing Fundamentals: A Comprehensive Guide for IT Professionals, Wiley, 2001.

CS 626	INTRUSION DETECTION SYSTEMS	3 Credits [3-0-0]
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Introduction to data and methodologies of computer intrusion detection, statistical & machine approaches to detection of attacks on computers, techniques for studying the Internet & estimating the number & severity of attacks, network based attacks such as probes & denial of service attacks, host based attacks such as buffer overflows and race conditions, malicious codes such as virus and worms, statistical pattern recognition for detection & classification of attacks, techniques for visualizing networked data etc. Special topics in intrusion detection systems.

**Essential Reading:**

1. S. McClure, S. Shah, Shreeraj. Shah, We Hacking, Pearson Press.
2. D. Litchfield, C. Anley et. al., Database Hacker's handbook, Wiley Publishers.

**Supplementary Reading:**

1. S. McClure, J. Scambray, G. Kurtz, Hacking Exposed, TMH.



CS 627	WIRELESS NETWORK SECURITY	3 Credits [3-0-0]
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Wired/wireless networks, effect of mobility on networks & systems, impact on IP stack from MAC layer and up. Ad hoc and sensor networks, wireless broadcasts, IP broadcasts, satellite broadcasts, issues of information capacity, distinction between wired & wireless from information theory, issues of securities in wireless, issues of 802.11 protocols, routing in wireless networks, design of secure protocols, key distribution for access control, source authentication of transmissions and non repudiation, power management & selfishness issues, attacks in wireless networks, DOS & DDOS attacks, reaction to attacks, information processing for sensor networks. Special topics in wireless network security.

**Supplementary Reading:**

1. J. R. Vacca, Guide to Wireless Network Security, Springer Verlag, 2006.
2. Tara M. Swaminatha, C. R. Elden, Wireless Security & Privacy, Pearson Press, 2007.

CS 628	WIRELESS SENSOR NETWORKS	3 Credits [3-0-0]
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Introduction to wireless sensor network: Application and Motivation, Network Performance objective, Development of Wireless Sensor Network; Canonical Problem Localization and Tracking: Tracking Multiple Objects, State space decomposition, Data association, Sensor Models, Performance Comparison and Metrics; Networking Sensors: The S MAC Protocol, IEEE 802.15.4 Standard and ZigBee, Routing in sensor network; Infrastructure Establishment: Topology Control, Clustering, Time Synchronization, Clocks and Communication Delays, Sensor Tasking and Control; Sensor Network Databases: Sensor Database Challenges, Querying The Physical Environment, Query Interfaces, Cougar sensor database and abstract data types, Probabilistic queries, High level Database Organization, In Network Aggregation, Query propagation and aggregation, TinyDB query processing, Query processing scheduling and optimization, Data Centric Storage. Special topics in wireless sensor networks.

**Essential Reading:**

1. F. Zhao and L. Guibas, Wireless Sensor Network: Information Processing Approach, Elsevier.
2. E. H. Callaway, Jr. E. H. Callaway, Wireless Sensor Networks Architecture and Protocols: CRC Press.

**Supplementary Reading:**

1. A. Hac, Wireless Sensor Network Designs, John Wiley & Sons

CS 629	NETWORK SECURITY	3 Credits [3-0-0]
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Network architecture, attacks, covert channels, Security at the Application Layer (PGP and S/MIME), email, PGP, S/MIME, MIME, S/MIME. Security at the Transport Layer (SSL and TLS): SSL architecture, Protocols : Handshake, changecipherspec, alert, record, SSL Message format, Transport Layer Security. Security at the Network Layer(IPSec): Modes, Two security protocols, Security association, security policy, Internet key exchange, ISAKMP. Recent trends in network security.

**Essential Reading:**

1. B. A. Forouzan, Cryptography & Network Security, McGraw Hill, Special Indian Edition, 2007.
2. W. Stallings, Cryptography and Network Security, Pearson Education, 3rd Ed, 2006.

**Supplementary Reading:**

1. N. Krawety, Introduction to Network Security, Thompson, Special India Ed, 2007.

CS 630	ARTIFICIAL INTELLIGENCE	3 Credits [3-0-0]
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AI Techniques, Production systems, State space representation and search methods, A \* and AO \* algorithms, game tree, Knowledge representation: predicate calculus, semantics nets, conceptual dependency, frames and

scripts, perception and knowledge acquisition. Introduction to Natural language processing, Expert systems, Non monotonic reasoning, Man Machine interface, Question answering, Computer vision etc., Simple Case Study. Special topics in artificial intelligence.

**Essential Reading:**

1. E. Rich and K. Knight : Artificial Intelligence , Tata Mc Grawhill,
2. N.J. Nilsson : Principles of Artificial Intelligence , Narosa,

**Supplementary Reading:**

1. G. F. Luger Wa Stubblefield : Artificial Intelligence, Addison Wisley
2. S. L. Tanimotto: The Elements of Artificial Intelligence, Computer Science Press.

CS 631	INFORMATION THEORY AND CODING	3 Credits [3-0-0]
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Introduction to information Theory, Information and entropy, properties of entropy of a binary memory less source, Measure of Information, Source Coding, Shannon Fano coding, Huffman coding, Lempel Ziv coding, channel coding, Channel capacity, noisy channel coding theorem for DMC. Linear block codes, generator matrices, parity check matrices, encoder syndrome and error detection minimum distance, error correction and error detection capabilities, cyclic codes, coding and decoding. Coding convolutional codes, encoder, generator matrix, transform domain representation state diagram, distance properties, maximum likelihood decoding, Viterbi decoding, sequential decoding, interleaved convolutional codes. Special topics in information theory and coding.

**Essential Reading:**

1. R. Bose, Information Theory Coding and Cryptography, Tata McGraw Hill, 2003.
2. F. J. MacWilliams, N. J. A. Sloane, The Theory of Error Correcting Codes, Elsevier, 1977.

**Supplementary Reading:**

1. S. Roman, Coding and Information Theory, Springer, 1992.
2. R. J. McEliece, The Theory of Information and Coding, Cambridge Univ Press, 2004.
3. T. M. Cover, J. A. Thomas, Elements of Information Theory, Wiley, 1991.

CS 632	DISTRIBUTED OPERATING SYSTEMS	3 Credits [3-0-0]
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Introduction to parallel Computing, Solving problems in parallel, Structures of parallel computers, Instruction level parallel processing, Parallel Algorithms, Parallel programming, Operating Systems for parallel computers, Performance Evaluation of parallel computers.

Characterization of distributed systems, Design goals, Communication and computer networks, Distributed processing, Distributed operating systems, Client Server Communications, Remote Procedure calls, File Service, Name Service, Distributed transactions and concurrency control, fault tolerance and security. Synchronization & Coordination, Distributed Algorithms, research issues. Special topics in distributed operating systems.

**Essential Reading:**

1. G. Coulouroris, J. Dollimore & T. Kindberg, Distributed Systems: Concepts and Design, Addison-Wesley, 3rd ed, 2001.
2. M. Singhal & N. G. Shivaratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.

**Supplementary Reading:**

1. P. K. Sinha, Distributed Operating Systems, IEEE Press, 1997.
2. H. F. Jordan, Fundamentals of Parallel Processing, Pearson, 2004.

3. C. Hughes & T. Hughes, Parallel and Distributed Programming Using C++, Pearson, 1st Ed, 2004.
4. W. Buchanan, Distributed Systems and Networks, Tata McGraw Hill, 2004.
5. P. S. Pacheco, Parallel Programming with MPI, Morgan Kaufmann, 1997.

CS 633	GAME THEORY	3 Credits [3-0-0]
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Basic Solution concepts and computational issues: Games, Old and New; Games Strategies, Costs and Payoff;; Basic Solution Concepts; Finding equilibria and Learning in Games. Refinement of Nash: Games with Turns and Sub game Perfect Equilibrium: Cooperative games, markets and their Algorithmic Issues. The Complexity of finding Nash Equilibria: Introduction, Is Lemke Howson algorithm, succinct representation of games. Graphical Games: Computing Nash equilibria in Tree Graphical Games, Graphical Games and correlated Equilibria, Cryptography and Game theory: Cryptographic notation and settings, game theory notation and settings, cryptographic influence on game theory and Game theoretic influence on cryptography. Distributed algorithmic mechanism design : two examples of DAMD, Interdomain routing Cost sharing. Incentive and Pricing in Communication Networks Large network Competitive model, Pricing and Resource allocation Game theoretic model Incentive and Information security: Misaligned incentive Informational Asymmetries, Complex network and topology. Special topics in game theory.

**Essential Reading:**

1. M. J. Osborne & A. Rubinstein, A Course in Game Theory, MIT Press, 2001.
2. M. J. Osborne, An Introduction to Game Theory, Oxford University Press, 2004.

**Supplementary Reading:**

1. N. Nisan, T. Rougharden, E. Tardos & V. V. Vazirani, Algorithmic Game Theory, Cambridge University Press, 2004.
2. K. Binmore, Fun and Games: A text on Game theory, AIBS publisher, 2004.

CS 634	BIOINFORMATICS	3 Credits [3-0-0]
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**Pre requisite Knowledge on following is necessary:**

1. Genetics
2. Cell and Molecular Biology
3. Biochemistry

Introduction; Databases mapping, sequence, structure, non redundant; Sequence alignment pair wise and multiple; phylogenetics; Structure prediction methods homology, threading, abinitio; Sequence analysis class and secondary structure prediction; motifs PROSITE; detecting functional sites in DNA; OR Finder; Computer science perspective pattern recognition, hidden Markov models; Data Mining using Soft computing Techniques. Special topics in bioinformatics.

**Essential Reading:**

1. A. D. Baxeavanis & B. F. F. Ouellette, Bioinformatics, Wiley Interscience, 1998.
2. A. M. Lesk, Introduction to bioinformatics, OXFORD University Press, 1st Ed, 2003.

**Supplementary Reading:**

1. S. L. Salzberg, D. B. Searls and S. Kasif eds, Computational methods in molecular biology, Elsevier, 1998.
2. R. F. Doolittle, Computer methods for macromolecular sequence analysis, Academic Press, 1996.
3. M. Bishop, Guide to human genome computing, Academic Press.

CS 635	BIOMETRIC SECURITY	3 Credits [3-0-0]
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Security via biometrics, space domain based biometrics and recognition techniques. Correlation based

biometric filters, Basic theory of correlation filters, Design of advanced correlation filters that offer tolerance to expected impairments, methods to implement digital correlation, applications of correlation filters. Special topics in biometric security.

**Essential Reading:**

1. P. Reid, Biometrics for Network Security, Pearson Press.
2. J. D. Woodward, N.M.Orlans, P.T.Higgins, Biometrics, Dreamtech Publishers.

**Supplementary Reading:**

1. S. Nanavati, M. Thieme, R. Nanavati, Biometrics, Wiley Publishers.

CS 636	IMAGE PROCESSING	3 Credits [3-0-0]
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The DFT and Digital Convolution: The DFT and its relationship to other transforms, properties of the DFT, FFT, DIT and DIF FFT algorithms, prime factor FFT algorithms, Analysis and Design of discrete time systems in the frequency domains, Frequency domain characteristics of LTI systems, LTI frequency selective filters, linear filtering method based on DFT, the Goertzel algorithm and chirp Z transform algorithm. Inverse systems and Deconvolutions, Realisation of discrete systems: Design of digital filters, Quantization effects in Digital Signal Process, Power Spectrum Estimation, Adaptive Filters. Recent advances in signal processing applications.

**Essential Reading:**

1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall of India, 3rd Ed, 1996, reprint 2005.

**Supplementary Reading:**

1. V. Oppenheim & R. W. Schaffer, Digital Signal Processing, Prentice Hall of India, 8th Ed, 2002.
2. S. W. Smith, Digital Signal Processing: A Practical Guide for Engineers and Scientists, Newness – Elsevier Science, 1st Ed, 2002.

CS 637	DIGITAL SIGNAL PROCESSING	3 Credits [3-0-0]
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Two Dimensional Systems & Mathematical Preliminaries: Linear Systems and Shift Invariance; the Fourier Transform; Optical and Modulation Transfer Functions; Matrix Theory Results; Block Matrices and Kronecker Products; Random Signals; Discrete Random Fields; the Spectral Density Function; Some results from information theory. Image Perception, Image Sampling and Quantization, Image Transforms, Image Enhancement, Image Filtering and Restoration, Image Analysis and Computer Vision Spatial Feature Extraction; Transform Features; Edge Detection; Boundary extraction; Boundary, Region, Moment Representation; Structure; Shape Features; Texture; Scene Matching and Detection; Image Segmentation; Classification Techniques; Image Understanding. Image Reconstruction from Projections, Image Data Compression. Recent advances in image processing.

**Essential Reading:**

1. R. C. Gonzalez & R. E. Woods, Digital Image Processing, Prentice Hall, 3rd ed, 2008.
2. A. K. Jain, Fundamentals of Digital Image Processing, Prentice Hall of India, 2002.

**Supplementary Reading:**

1. W. K. Pratt, Digital Image Processing, Wiley Interscience, 4th ed, 2007.
2. Rosenfeld & A. C. Kak, Vol.I, Digital Picture Processing, Academic Press, 1976.

CS 638	PATTERN RECOGNITION	3 Credits [3-0-0]
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Introduction to pattern recognition, statistical pattern recognition, decision trees, classification using decision trees, obtaining Prules from decision trees, missing attribute values, error rates on recall sets, pruning decision trees, obtaining Prules by evolution, Bayes classification, estimation of probabilities, nearest neighbor

classification, performance issues of a nearest neighbor classifier, Neural classifier, training of neural classifier, clustering, Agglomerative hierarchical clustering, K means clustering, syntactic pattern recognition. Recent advances in pattern recognition.

**Essential Reading:**

1. Rajjan Shighal, Pattern Recognition: Techniques and Applications, Oxford University Press, 1st ed, 2006.
2. Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1st ed, 2003.

**Supplementary Reading:**

1. W. Gibson, Pattern Recognition, Berkley Press, 1st Ed, 2005.
2. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 1st Ed, 2007.

CS 639	SOFT COMPUTING	3 Credits [3-0-0]
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Introduction to Neorofuzzy and Soft Computing, Fuzzy set theory, Fuzzy Rules, Fuzzy Reasoning, Fuzzy inference System, Neural Networks; Radial basis and recurrent neural networks, Hopfield Networks, Comparision of RBF and MLP Network, Running Algorithms, NeuroFuzzy Modeling, Applications of Soft Computing to Signal Processing, Image Processing, Forecasting, XOR Problem traveling salesman problem, Image compression suing MLPs character retrieval using Hopfield networks, Introduction to Genetic Algorithm hybrid systems etc. Recent advances in soft computing applications.

**Essential Reading:**

1. V. Kecman, Learning and Soft Computing, Pearson, 1st Ed, 2001.
2. D. E. Goldberg, Genetic Algorithms in Search Optimization and Machine Learning, Addison Wesley, 3rd Ed.

**Supplementary Reading:**

1. B. Kosko, Neural Network and fuzzy systems, Prentice Hall of India, 2006.
2. S. Goonatilake & S. Khebbal, Intelligent Hybrid Systems, Wiley, 1995.

CS 641	ADVANCED COMPUTER ARCHITECTURE	3 Credits [3-0-0]
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Metrics for computer performance: clock rate, MIPS, CPI; Strength and weakness of performance metrics; role of Amdalh's in computer performance; Classification of computer architecture: SIMD, MIMD, SISD and MISD; Processing unit design: Data path implementation, Microprogrammed execution. Instruction pipelining and parallel processing, Instruction level parallelism: VLIW, Vector processor, Multithreaded processor, Superscalar architecture; branch prediction; Prefetching; Speculative execution; Principles of pipelining and vector processing: Pipelining, Instruction and Arithmetic Pipelines, Principles of Designing Pipelined Processor, Vector Processing Requirements. Structure and Algorithms for array processors: SIMD Array Processors, SIMD Interconnection Networks, Parallel Algorithms for array Processors, Associative Array Processing. Multiprocessor architecture and programming: Inter processor Communication Mechanisms, System Deadlocks and Protection, Multiprocessor Scheduling Strategies, Parallel Algorithm for Multiprocessor. Multiprocessor architecture. Recent advances in computer architecture.

**Essential Reading:**

1. K. Hwang and F. A. Briggs, Computer Architecture and Parallel Processing, McGraw Hill, 2001.
2. N. Carter, Computer Architecture, Tata McGraw Hill, 3rd ed. 2008.

**Supplementary Reading:**

1. J. L. Heressy and D. A. Pattersan, Computer Architecture A Quantitative approach, Elsevier, 3rd ed. 2006.
2. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, Tata McGraw Hill, 2004.

CS 642

CLUSTER AND GRID COMPUTING

3 Credits [3-0-0]

Introduction: High Performance Computing (HPC), Grand Challenge Problems Computational and communication intensive, Parallel Architectures Classifications SMP, MPP, NUMA, Clusters and Components of a Parallel Machine, Conventional Supercomputers and its limitations, Multi-processor and Multi Computer based Distributed Systems. Cluster and Grids: Cluster Components Processor/machine, High Speed Interconnections goals, topology, latency, bandwidth, Example Interconnect: Myrinet, Infiniband, QsNet, Fast Ethernet, Gigabit Ethernet, Light weight Messaging system/Light weight communication Protocols, Cluster Middleware Job/Resource Management System, Load balancing, Scheduling of parallel processes, Enforcing policies, GUI, Introduction to programming tools such as PVM, MPI, Cluster Operating Systems Examples: Linux, MOSIX, CONDOR, Characteristics of Grid, Computational services, Computational Grids, Data grids/ Storage grids, management and applications, Different components of Grid Grid fabric, Grid middleware, Grid applications and portal, Globus toolkit Ver.2.4, web services, MDS,GRAM, Grid Security –Cryptography, Authentication, Integrity, Digital Signature, Digital Certificates, Certificate Authority, MD 5, RSA, GSI,GSSAPI, Directory Service, LDAP,GRID FTP,GASS Fault Tolerance: Fault detection and diagnosis of Clusters and Grids. Recent advances in cluster and grid computing.

**Essential Reading:**

1. D. Janakiram, Grid Computing, Tata McGraw Hill, 2005.
2. R. K. Buyya, High Performance Cluster Computing: Programming and Applications, Vol 2, PHI, NJ, USA, 1999.

**Supplementary Reading:**

1. P. Jalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994.
2. J. J. Jos & R. K. Buyya, High Performance Cluster Computing: Architecture and Systems, Vol 1, PHI, NJ, USA, 1999.
3. R. K. Buyya & C. Szyperski, Cluster Computing, Nova Science, New York, USA, 2001.
4. R. K. Buyya & K. Bubendorfer, Market oriented Grid and Utility Computing, Wiley, 2008.
5. J. Jaseph & C. Fellenstein, Grid Computing, Pearson, 1st Wd, 2004.

CS 643

EMBEDDED SYSTEMS

3 Credits [3-0-0]

Introduction: Embedded system, Processor, hardware units, software embedding, SOC, NOC, VLSI circuit; Device and Device drivers, I/O devices, timer and counting devices, serial communication using IC, LAN and advanced I/O buses between the networked multiple devices, Host system, parallel communication using ISA, PCI, PCI X, and advanced buses, device drivers, parallel port device drivers in a system, serial port device drivers. Interrupt service handling mechanism; Software and programming concepts: processor and memory selection for embedded system, embedded programming in C++, Java and UML, multiple processes and applications, problem of sharing data by multiple tasks and routines, interprocess communication; Real time OS: OS services, I/O subsystem, Network OS, Real time Embedded system, Need of well tested and debugged RTOS, Introduction to C/OS II. Case Studies of programming with RTOS: Smart card embedded system, Hardware and Software co design: specification and design of an embedded system, use of software tools for development of an embedded system. Recent advances in embedded applications.

**Essential Readings:**

1. R. Kamal, Embedded System Architecture, Programming and Design, Tata McGraw Hill, 2005.
2. R. Niemann, Hardware Software Codesign of Embedded System, Kulwer Academic, 2006.

**Supplementary Readings:**

1. S. V. Iyer & P. Gupat, Embedded Real Time System Programming, Tata McGraw Hill, 2004.

2. W. Wolf, Computer as Components: Principles of Embedded Computer System Design, Elsevier, 2005.
3. S. Heath, Embedded System Design, 2nd ed, Elsevier, 2005.
4. R. Mall, Real Time Systems Theory and Practice, Pearson, 2008.
5. F. Vahid & T. Givargis, Embedded Ssystem design: A unified Hardware/Software approach, Wiley, 2007.
6. G. D. Michelli & L. Benin, Network on Chip, Morgan & Kaufman Publication, 2004.

CS 644	FAULT TOLERANT COMPUTING	3 Credits [3-0-0]
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Introduction to Fault Tolerant Computing. Basic concepts and overview of the course; Faults and their manifestations, Fault/error modeling, Reliability, availability and maintainability analysis, System evaluation, performance reliability trade offs. System level fault diagnosis, Hardware and software redundancy techniques. Fault tolerant system design methods, Mobile computing and Mobile communication environment, Fault injection methods, Software fault tolerance, Design and test of defect free integrated circuits, fault modeling, built in self test, data compression, error correcting codes, simulation software/hardware, fault tolerant system design, CAD tools for design for testability. Information Redundancy and Error Correcting Codes, Software Problem. Software Reliability Models and Robust Coding Techniques, Reliability in Computer Networks Time redundancy. Re execution in SMT, CMP Architectures, Fault Tolerant Distributed Systems, Data replication. Case Studies in FTC: ROC, HP Non Stop Server. Case studies of fault tolerant systems and current research issues.

#### Essential Readings:

1. D. K. Pradhan, editor, Fault Tolerant Computer System Design, Prentice Hall, 1996.
2. I. Koren. Fault Tolerant Systems, Morgan Kauffman 2007.

#### Supplementary Readings:

1. L. L. Pullum, Software Fault Tolerance Techniques and Implementation, Artech House Computer Security Series, 2001.
2. M. L. Shooman, Reliability of Computer Systems and Networks Fault Tolerance Analysis and Design, Wiley, 2002

CS 645	PARALLEL ALGORITHMS	3 Credits [3-0-0]
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Modeling; Synchronous Network Model, Leader Election in a Synchronous Ring, Algorithms in General Synchronous Networks, Distributed Consensus with Link Failures, Distributed Consensus with Process Failures, More Consensus Problems, Asynchronous System Model, Asynchronous Shared Memory model, Mutual Exclusion, Resource Allocation, Consensus, Atomic Objects, Asynchronous Network Model, Basic Asynchronous Network Algorithms, Synchronizers, Shared Memory versus Networks, Logical Time Global Snapshots and stable properties, Network Resource allocation, Asynchronous Networks with Process Failures, Data Link Protocols, Partially Synchronous Models, Mutual Exclusion with Partial Synchrony, Consensus with Partial Synchrony. Recent advances in parallel algorithms.

#### Essential Reading:

1. B. Wilkinson & M. Allen, Parallel Programming, Pearson, 2nd ed, 2005.
2. M. J. Quinn, Parallel Programming in C with MPI and OpenMP, Tata McGraw Hill, 2003.

#### Supplementary Reading:

1. W. Groop, E. Lusk & A. Skjellum, Using MPI: Portable Parallel Programming with the Message passing Interface, MIT Press, 1999.
2. H. F. Jordan and G. Alagband, Fundamentals of Parallel Processing, Pearson, 1st Ed, 2003.
3. G. V. Wilson & G. Wilson, Practical Parallel Programming, MIT Press, 1995.



CS 646

PARALLEL AND DISTRIBUTED COMPUTING

3 Credits [3-0-0]

Introduction to parallel Computing, Solving problems in parallel, Structures of parallel computers, Instruction level parallel processing, Parallel Algorithms, Parallel programming, Operating Systems for parallel computers, Performance Evaluation of parallel computers; Characterization of distributed systems, Design goals, Communication and computer networks, Distributed processing, Distributed operating systems, Client Server Communications, Remote Procedure calls, File Service, Name Service, Distributed transactions and concurrency control, fault tolerance and security. Synchronization & Coordination, Distributed Algorithms, research issues.

**Essential Reading:**

1. G. Coulouroris, J. Dollimore & T. Kindberg, Distributed Systems: Concepts and Design, Addison Wesley, 3rd ed, 2001.
2. M. Singhal & N. G. Shivaratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.

**Supplementary Reading:**

1. P. K. Sinha Distributed Operating Systems, IEEE Press, 1997.
2. H. F. Jordan, Fundamentals of Parallel Processing, Pearson, 2004.
3. C. Hughes and T. Hughes, Parallel and Distributed Programming Using C++, Pearson, 1st ed, 2004.
4. W. Buchanan, Distributed Systems and Networks, Tata McGraw Hill, 2004.
5. P. S. Pacheco, Parallel Programming with MPI, Morgan Kaufmann, 1997.

CS 647

PERFORMANCE EVALUATION OF COMPUTER SYSTEMS

3 Credits [3-0-0]

Introduction to Probability Refresher: Bayes theorem, Conditional probability, Total probability, Discrete and Continuous Random variables, Common distributions, Probability Generating Functions(PGF) and Laplace Transforms(LST), Numerous examples from computer networking, Stochastic processes, Discrete time Markov chains (DTMC), Continuous time Markov chains (CTMC), Queueing systems (M/M/1, M/M/c/k, M/G/1), Queueing networks, Statistical analysis of simulations, Specific topics: Introduction to performance measures, basic probability review, Markov chains, basic queueing models, introduction to simulation modeling, some advanced queueing models, basic queueing networks, examples from recent research papers.

**Essential Reading:**

1. Kishor Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Applications, PHI, 2005.
2. Law and Kelton, Simulation Modeling and Analysis, 2nd Ed., McGraw Hill, 1991.
3. D. Gross and C. M Harris, Fundamentals of Queueing Theory, John Wiley and Sons, 1974.
4. L. Kleinrock, Queueing Systems Vol. I & II, John Wiley and Sons, 1975.

**Supplementary Reading:**

1. For a primer in Probability, this On Line Book from Dartmouth College can be referenced.
2. A gentle introduction to some basic queueing concepts, by William Stallings, PHI.
3. Quantitative Systems Performance, an on line version of the book on queueing networks by Edward D. Lazowska, John Zahorjan, G. Scott Graham, Kenneth C. Sevcik.

CS 648

SECURITY AND FAULT TOLERANCE IN DISTRIBUTED SYSTEM

3 Credits [3-0-0]

Introduction: High Performance Computing (HPC), Grand Challenge Problems Computational and communication intensive, Parallel Architectures Classifications SMP,MPP,NUMA,Clusters and Components of a Parallel Machine, Conventional Supercomputers and it's limitations, Multi-processor and Multi Computer based Distributed Systems, Introduction to Clusters and Grids. Fault Tolerance: Classification of faults , Fault

detection, fault diagnosis, fault model, hardware and software redundancy Masking/Non masking –Group and Hierarchical masking, Reliability and availability, Code protection/data protection (RAID LEVEL 0 5), Dependable Clusters high availability and high performance clusters. Dependability Concepts, Quorums, Consensus and Broadcast, View synchronous Group Communication, Distributed Cryptography, Byzantine Agreement, Service Replication, Data Storage. System Level diagnosis: Diagnosis and Diagnosability Theory, Testing Assignment, Syndrome Collection, Centralized vs. Distributed Diagnosis, Static Vs. Dynamic Fault Environment, System and Fault Model, Classification of Diagnosis Algorithms, Evaluation Metric such as Time and Space Complexity, Bounded Correctness, Applications to Distributed Embedded System, Internet, DSNs, MANETs, PVN. Fault Tolerant Networks: Measures of Resilience, Graph Theoretic Measures, Computer Network Measures, Regular Networks, Adhoc Point to point Networks. Fault Detection in Cryptographic Systems: Overview of Ciphers, Symmetric Ciphers, Public Key Ciphers, Security Attacks Through Fault Injection, Fault Attacks on Symmetric/ Asymmetric Key Ciphers, Counter Measures: Spatial and Temporal Duplication, Error Detecting Codes. Recent advances in security and fault tolerance in distributed system.

#### **Essential Reading:**

1. P. Jalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994.
2. J. Joseph & C. Fellenstein, Grid Computing, Pearson Education, 1st Ed, 2004.

#### **Supplementary Reading:**

1. H. Attiya and J. Welch, Distributed Computing: Fundamentals, Simulations and advanced Topics. Wiley, 2nd edition, 2004
2. G. Coulouris, J. Dollimore, and T. Kindberg. Distributed Systems: Concepts and Design. Addison Wesley, 3rd edition, 2001.
3. S. Koren, C. M. Krishna, Fault Tolerant systems, Morgan Kaufman Publishers, 2007.

CS 649	VLSI SYSTEM DESIGN	3 Credits [3-0-0]
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Deep sub micron digital IC design; Transistors and Devices: MOS transistors; Bipolar transistors and circuits; Fabrication: IC fabrication technology; Simulation: Modeling the MOS transistor for Circuit Simulation; Silicon on Insulator technology; MOS Inverter circuits: Voltage transfer characteristics; Noise margin definitions; NMOS transistors as load devices; CMOS inverter. Static MOS Gate circuits: CMOS gate circuits; Complex CMOS Gates; XOR and XNOR Gates; Flip Flops and Latches; Semiconductor memory design: MOS decoder; Static RAM cell design; RAM column I/O circuitry; Power Grid and Clock design: Power distribution design; clocking and timing issues; Phase locked loop/Delayed locked loop. Recent advances in VLSI design.

#### **Essential Reading:**

1. D. A. Hodges, H. G. Jackson & R. A. Saleh, Analysis and Design of Digital Integrated circuits, Tata McGraw Hill, 3rd ed. 2008.
2. D. A. Pucknell & K. Eshraghian, Basic VLSI Design, Prentice Hall of India, 3rd ed. 2001.

#### **Supplementary Reading:**

1. W. H. Wolf, Modern VLSI Design System on chip design, Prentice Hall of India, 3rd ed. 2004.
2. C. Mead & L. Conway, Introduction to VLSI system, Addison Wesley, 2004.

CS 650	SOFTWARE METRICS	3 Credits [3-0-0]
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Basics of measurement: scope of software metrics, representational theory of measurement, measurement and models, measurement scales, meaningfulness in measurement, goal-based framework for software, measurement, Software-metrics data collection and analysis: What is good data, how to define the data, how to collect the data, how to store and extract data, analyzing software-measurement data, frequency distributions, various statistical techniques. Measuring internal product attributes: Measuring external product

attributes: Modeling software quality, measuring aspects of software quality, software reliability, basics of software reliability, software reliability problem, parametric reliability growth models, predictive accuracy, recalibration of software-reliability growth predictions, importance of operational environment, wider aspects of software reliability. Metrics for object-oriented systems: The intent of object-oriented metrics, distinguishing characteristics of object-oriented metrics, various object-oriented metric suites – LK suite, CK suite and MOOD metrics. Metrics for component-based systems: The intent of component-based metrics, distinguishing characteristics of component-based metrics, various component-based metrics. Resource measurement: Measuring productivity, teams, tools, and methods.

**Essential Reading:**

1. N.E. Fenton and S.L. Pfleeger; Software Metrics – A Rigorous and Practical Approach, Thomson Asia Pte., Ltd, Singapore.
2. S.H. Kan; Metrics and Models in Software Quality Engineering, Addison Wesley, New York.

**Supplementary Reading:**

1. K. H. Möller and D. J. Paulish; Software Metrics - A Practitioner's Guide to Improved Product Development, Chapman and Hall, London.
2. M. Lorenz and J. Kidd; Object-Oriented Software Metrics, Prentice Hall, New York.

CS 651	SOFTWARE RELIABILITY	3 Credits [3-0-0]
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Software Reliability: Basic Ideas of Software Reliability, Computation of software reliability, Classes of software reliability Models. Time Dependent Software Reliability Models: Time between failure reliability Models, Fault Counting Reliability Models. Time Independent Software Reliability Models: Fault injection model of Software Reliability, Input Domain Reliability Model, Orthogonal defect classification, Software availability Models. Software Reliability Modeling: A general procedure for reliability modeling.

**Essential Reading:**

1. H. Pham, Software Reliability, Springer Verlag, New York.
2. J.D. Musa, Software Reliability Engineered Testing, McGraw Hill, New York.

**Supplementary Reading:**

1. D. Reled, Software Reliability Methods, Springer Verlag, New York
2. R. Ramakumar, Reliability Engineering: Fundamentals and Applications, Prentice Hall, New Delhi.

CS 652	SOFTWARE ARCHITECTURE	3 Credits [3-0-0]
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Architectural styles, Pipes and Filters, Data abstraction and object oriented organization, Event based, implicit invocation, Layered systems, Repositories, Interpreters, Process Control, Other familiar architectures, Heterogeneous architectures, Shared information systems, Database Integration, Integration in Software Development Environments, Integration in the design of buildings, Architectural Structures for Shared Information Systems, Guidance for user interface architectures, The quantified Design space, The value of architectural formalism, Formalizing the architecture of a specific system, Formalizing an architecture Style, Toward a theory of Software Architecture, Z Notation used, Requirements for Architectural description Languages, First Class Connectors, Adding Implicit Invocation to Traditional Programming Languages. ; Unicon: A Universal Connector Language, Exploiting style in Architectural Design Environments, Beyond Definition/Use: Architectural Interconnection.

**Essential Reading:**

1. C. Paul, K. Rick and K. Mark, Evaluating Software Architecture: Methods and Case Studies, Pearson Education, 2007.
2. Sreve and B. Paul, Patterns for Effective Use Cases, Pearson Education, 2006.

**Supplementary Reading:**

1. Baroca L, and P. Hall, Software Architecture: Advances and Applications, Springer Verlag, 2000.
2. M.Shaw and D.Garlan; Software Architecture: perspectives on an emerging discipline, Eastern Economy Edition.
3. Bosch. J, Design and Use of Software Architectures, Addison-Wisley, 2000.

CS 653	SOFTWARE PROCESS	3 Credits [3-0-0]
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Identifying process issues, Selecting and defining measures , Integrating measures with the software process ; Principal tasks, Specifics of collecting software process data, Reviewing and Assessing Collected data, Retaining data, Tools for understanding your data, Separating signals from noise, Evaluating process stability, Control chart basics, Control charts for variables or discrete data , Control charts for attributes data, Anomalous process behavior patterns, Rational sampling and homogeneity of subgroups, Rational sub grouping, The problem of insufficient granularity in recorded values, Aggregation and decomposition of process performance data, Process capability, Process capability analysis, Improving the process, Improvement and investment.

**Essential Reading:**

1. W.A. Florac and A.D. Carleton, Measuring the Software Process: Statistical process control for software process improvement, Pearson Education, 2007.
2. Card David N. and Glass, Robert L., Measuring Software Design Quality, Englewood Cliffs, NJ, PH, 1990.

**Supplementary Reading:**

1. Austin, Robert D, Measuring and managing Performance in Organizations, New York, Dorset House Publishing Company, 1996.

CS 654	SOFTWARE AGENT	3 Credits [3-0-0]
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Agent Definition, Agent Programming Paradigms, Agent Vs Object, Aglet, Mobile Agents, Agent Frameworks, Agent Reasoning, Interface Agents: Metaphors with Character, Processes, threads, daemons, Components, Java Beans, ActiveX, Sockets, RPCs, Distributed Computing, Agent–Oriented Programming, Jini Architecture, Actors and Agents, Typed and proactive messages, Interaction between agents, Reactive Agents, Cognitive Agents, Interaction protocols, Agent coordination, Agent negotiation, Software Agent for Cooperative Learning, Agent Organization, Self - interested agents in electronic commerce applications, Interface Agents, Agent Communication Languages, Agent Knowledge representation, Agent adaptability, Agent-Based Framework for Interoperability, Agents for Information Gathering, Belief Desire Intension, Mobile Agent Applications, Towards an Industrial-Strength Open Agent Architecture, Agent Security Issues, Mobile Agents Security, Protecting Agents against Malicious Hosts, Untrusted Agent, Black Box Security, Authentication for agents, Security issues for aglets.

**Essential Readings:**

1. Jeffrey M. Bradshaw, " Software Agents ", MIT Press, 2000.
2. Richard Murch, Tony Johnson, "Intelligent Software Agents", Prentice Hall, 2000.

**Supplementary Readings:**

1. Bigus & Bigus, " Constructing Intelligent agents with Java ", Wiley, 1997.
2. Gerhard Weiss, "Multi Agent Systems – A Modern Approach to Distributed Artificial Intelligence", MIT Press, 2000.

CS 655	SOFTWARE DESIGN PATTERN	3 Credits [3-0-0]
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Introduction, Review of the software development context in relation to design patterns, Advantages of using classes, The uses of inheritance in software design, The principle of strong typing and substitution,

Polymorphism with abstract classes and inheritance, introduction to UML, Design techniques for modifiability, The strategy Pattern, A case study: Designing A Document Editor- Design problems, document structure, formatting, embellishing the user interface, Creational Patterns: Abstract Factory, Builder, Creational Patterns: Factory Method, Prototype, Singleton, Structural Pattern: Adapter, Bridge, Structural Pattern: Composite, Decorator, Structural Pattern: Façade, Flyweight, Proxy, Discussion of structural patterns, Behavioural Patterns: Chain of Responsibility, Command, Interpreter, Behavioural Patterns: Iterator, Mediator, Memento, Behavioural Patterns: Observer, State, Strategy, Behavioural Patterns: Template Method, Visitor, Discussion of behavioural pattern, What to expect from design pattern, The pattern Community.

#### Essential Readings:

1. Gamma, Erich; Richard Helm, Ralph Johnson, and John Vlissides (1995). Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley. ISBN 0-201-63361-2.
2. Bruegge, Bernd; Dutoit, Allen H. (2007). Object-Oriented Software Engineering using UML, Patterns, And JAVA, Pearson Education, ISBN 81-7758-768-4, second edition.

#### Supplementary Readings:

1. Fowler, Martin (2002). Patterns of Enterprise Application Architecture. Addison-Wesley. ISBN 978-0-321-12742-6.
2. Hohpe, Gregor; Bobby Woolf (2003). Enterprise Integration Patterns: Designing, Building, and Deploying Messaging Solutions. Addison-Wesley. ISBN 0-321-20068-3.
3. Freeman, Eric T; Elisabeth Robson, Bert Bates, Kathy Sierra (2004). Head First Design Patterns. O'Reilly Media. ISBN 0-596-00712-4.

CS 656	SOFTWARE CONFIGURATION MANAGEMENT	3 Credits [3-0-0]
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Introduction : Evolution in the Software Life Cycle , Configuration Management as a Controlling Tool , Configuration Management Process as a Visibility Tool, Configuration Management as a Cost Saving Tool, Requirements for the Success of Configuration Management. Maintaining Product Integrity: Identifying Configuration Items, Establishing Baselines, Naming Configuration Items. Change Management: Types of change, Configuration Control Boards. Version Control: The Simultaneous Update Problem, Version Trees, Tools for Version Control , System Description Languages, Metrics. Configuration Management Planning: Content of Configuration Management Plans, Characteristics of Personnel.

#### Essential Readings:

1. E.H. Bersoff, V.D.Hendersom, and S.G. Siegel. Software Configuration Management, Englewood Cliffs, N.J., Prentice- Hall 1980.
2. W. A. Babich, Software Configuration Management, Addison-Wisley, 2006.

#### Supplementary Reading:

1. R.C. Gunther, Management Technology for software product engineering, New York, John Wiley, 2005.

CS 657	PRINCIPLES OF MANAGEMENT	3 Credits [3-0-0]
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Introduction to Management: Management as a Science or Art, Management and Administration; Management thought: Classical, Neo-classical, and Modern; Functions of Management: planning, organizing, directing, coordinating and controlling; Decision-making: Types, Process, Effective Decision-making, Rationality and Decision-making; Business Forecasting: Process, Forecasting Techniques, Factors Affecting; Organizational Design: Organization Structure, Formal & Informal Organization, Span of Management, Centralization & Decentralization; Authority & Responsibility: Power and Authority, Sources of Authority, Line and Staff, Delegation of Authority; Objectives: Objective Setting, Prerequisites, Management by Objectives; Business Environment: Business System, Objectives of Modern Business, Changing Business Environment and Management

Challenges, Essentials of Successful Business, Social and Ethical Issues in Management; Managerial Roles and Skills: Skills for Professional Manager - Technical and Managerial, Tasks and Roles of Effective Manager; Leadership: Types, Theories, Transformational Leadership; Employee Motivation: Issues, Theories, Elements of Sound Motivation; Conflict and Change Management: Causes of Conflict, Conflict Resolution Technique, Planned Vs. Reactive Change, Process of Initiating Change; Group Dynamics: Groups, Teams, Group Cohesiveness, Effective Teams; Organizational Effectiveness: Employee Empowerment and Involvement, Employee Engagement. Organizational Climate and Culture, Quality of work life, Learning organization and Knowledge management, approaches to effectiveness, factors affecting effectiveness and Likert's model of effectiveness.

#### Essential Reading:

1. H. Weihrich, M. V. Cannice and H. Koontz; Management: A Global and Entrepreneurial Perspective), TMH, 12/e, 2008.
2. J.A.F. Stoner, R. E. Freeman and Daniel R. Gilbert, Jr., Management, PHI, 6/e, 1995.

#### Supplementary Reading:

1. L. M. Prasad, Principles and Practice of Management, Sultan Chand & Sons, 6/e, 2004.
2. R. D. Agarwal, Organization and Management, TMH, 29th Reprint, 2007.

CS 659	SERVICE ORIENTED ARCHITECTURE	3 Credits [3-0-0]
<p>Roots of SOA, Characteristics of SOA, Comparing SOA to client-server and distributed internet architectures, Anatomy of SOA, How components in an SOA interrelate, Principles of service orientation, Roots of SOA, Characteristics of SOA, Comparing SOA to client-server and distributed internet architectures, Anatomy of SOA, How components in an SOA interrelate, Principles of service orientation, Service oriented analysis, Business-centric SOA, Deriving business services, service modeling, Service Oriented Design, WSDL basics, SOAP basics, SOA composition guidelines, Entity-centric business service design, Application service design, Taskcentric business service design, SOA platform basics, SOA support in J2EE, Java API for XML-based web services (JAX-WS), Java architecture for XML binding (JAXB), Java API for XML Registries (JAXR), Java API for XML based RPC (JAX-RPC), Web Services Interoperability Technologies (WSIT), SOA support in .NET, Common Language Runtime, ASP.NET, web forms, ASP.NET web services, Web Services Enhancements (WSE), WS-BPEL basics, WS-Coordination overview, WS-Choreography, WS-Policy, WSSecurity.</p>		

#### Essential Readings:

1. Thomas Erl, Service-Oriented Architecture: Concepts, Technology, and Design, Pearson Education, 2005
2. Dan Woods and Thomas Mattern, Enterprise SOA Designing IT for Business Innovation, First Editioned.: O'REILLY, 2006.

#### Supplementary Readings:

1. Kai Qian, Xiang Fu, Lixin Tao, Chong-Wei Xu, and Jorge L. Diaz-Herrera, Software Architecture and Design Illuminated.: Jones and Bartlett, 2010.
2. Len Bass, Paul Clements, and Rick Kazman, Software Architecture in Practice, 2nd ed.: Pearson Education.
3. Newcomer and Lomow, Understanding SOA with Web Services.: Pearson Education, 2005.

CS 660	KNOWLEDGE MANAGEMENT	3 Credits [3-0-0]
<p>The value of Knowledge, Knowledge Engineering Basics, Knowledge Economy, The Task and Organizational Content, Knowledge Management, Knowledge Management Ontology, Knowledge Model Components, Template Knowledge Models, Reflective Knowledge Models, Knowledge Model Construction, Types of</p>		



Knowledge Models, Knowledge Elicitation Techniques, Modeling Communication Aspects, Knowledge Management and Organizational Learning, Case Studies, Designing Knowledge Systems, Knowledge Codification, Testing and Deployment, Knowledge Transfer and Knowledge Sharing, Knowledge System Implementation, Advanced Knowledge Modeling, Value Networks, Business Models for Knowledge Economy, UML Notations, Project Management.

1. Essential Readings:
2. Guus Schreiber, Hans Akkermans, Anjo Anjewierden, Robert de Hoog, Nigel Shadbolt, Walter Van de Velde and Bob Wielinga, "Knowledge Engineering and Management", Universities Press, 2001.
3. Elias M.Awad & Hassan M. Ghaziri, "Knowledge Management", Pearson Education, 2003

#### Supplementary Readings:

1. C.W. Holsapple, "Handbooks on Knowledge Management", International Handbooks on Information Systems, Vol 1 and 2, 2003.
2. Shelda Debowski, "Knowledge Management", wileyindia, 2007

CS 670	DATA MINING LAB (PROGRAMMING LABORATORY - I)	2 Credits [0-0-3]
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No Description

CS 671	PROGRAMMING LABORATORY - II	2 Credits [0-0-3]
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To be assigned by the professor in charge of the lab keeping in view the Subjects taught in the semester.

CS 672	SOFTWARE ENGINEERING LABORATORY	2 Credits [0-0-3]
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#### For Questions 1 – 8, do the followings:

Prepare the SRS document. You should identify the appropriate requirements for each problem; Draw the Use Case diagrams, Domain Models, and Class Diagrams using Rational Rose. ; Draw the Sequence Diagrams and Collaboration Diagrams for each Use Case, using Rational Rose; Draw the State Chart Diagrams and Activity Diagrams using Rational Rose, wherever necessary; Develop the corresponding software using Java with an interactive GUI and appropriate Database ; Develop software to automate the bookkeeping activities of a 5 star hotel ; The local newspaper and magazine delivery agency wants to automate the various clerical activities associated with its business. Develop a software for this ; A small automobile spare parts shop sells the spare parts for vehicles of several makes and models. Each spare part is typically manufactured by several small industries. To streamline the sales and supply ordering, the shop owner wants to automate the activities associated with his business. Develop a software for this ; Develop software for the automation of the dispensary of NIT, Rourkela ; Develop a software for automating various activities of the Estate Office of NIT, Rourkela ; Develop a word processing software with some limited number of facilities such as making bold, italics, underline, cut, copy and paste etc ; Develop a graphics editor software package, using which one can create / modify several common types of graphics entities ; Develop a software for automating various activities of the department offices of NIT, Rourkela ; Write a C function for searching an integer value from a large sorted sequence of integer values stored in array of size 100, using the binary search method. Build the control flow graph of this function using any compiler writing tool. Write a program in Java to determine its cyclomatic complexity ; Write a program in Java to determine the number of defects still remaining after testing, using error seeding methodology.

CS 673	IMAGE PROCESSING LABORATORY	2 Credits [0-0-3]
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Understanding the image formation ; Exercise on image transformations ; Assignments on image enhancement by point processing ; Image enhancement in frequency domain ; Understanding the concept of image



degradation ; Realizing different approaches of restoration ; Implementation of different image compression techniques ; Detection of discontinuity, edge linking, boundary detection ; Region oriented segmentation ; Thematically oriented project for the entire duration of the course for individual students or group of students. Laboratory works are to be done in C or MatLab.

CS 674	NETWORK SIMULATION LABORATORY	2 Credits [0-0-3]
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Installation and configuration of NS2 ; Creating a network: nodes, links and queues ; Creating connections, traffic and computing routers ; Insertion of errors and analysis of trace file ; Simple project on NS2 – wired, wireless and combination of wired and wireless ; Implementation of new protocols in NS2

CS 675	SOFT COMPUTING LABORATORY	2 Credits [0-0-3]
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Implementation of selected soft-computing methods presented during the lecture ; Implementation of various learning strategies ; Realization of MLP, RBF, Hopfield networks etc ; Solving optimization problems ; Understanding and realizing Fuzzy Logic and Fuzzy inference ; Programming Genetic Algorithms ; Understanding probabilistic reasoning, rough sets, chaos ; Realization of hybrid approaches.

CS 676	CRYPTOGRAPHY LABORATORY - I	2 Credits [0-0-3]
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Simulation of the following experiments

1. Ciphers : Polyalphabetic, Monoalphabetic
2. DES
3. AES
4. RSA
5. Diffie – Hellmann
6. ECC
7. DSA using RSA and ECC
8. Blind Signatures
9. E – Voting
10. Smartcard

CS 678	OS AND DATABASE SECURITY LABORATORY	2 Credits [0-0-3]
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Installation of Oracle with administration features ; Study of Administration skills of any operating system ; Study of commands related to OS security and oracle security ; Study of File permissions in UNIX, Windows ; Implementation of Access control mechanisms ; Write a pair of programs in C or shell script to send and receive a message by a covert channel in UNIX ; Simulation of k Anonymity, l diversity and t closeness algorithms ; Developing a simple intrusion detection system to protect masquerading attacks ; Study of SQL Injection attacks and simulation of control strategies ; Other assignments suggested by the instructor

CS 679	NETWORK SECURITY LABORATORY	2 Credits [0-0-3]
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No Description

