1. CSL701 DATA STRUCTURE 4 CREDITS (3-0-2)
Prerequisite: Introduction to Computing

Random-access-machine model, concept of problem size, and asymptotic behaviour of time/space complexity.Estimation of time/space complexity by smooth functions and order notations.A simple example of worst-case time/space complexity analysis.Elementary data-structures: arrays, lists, queues, stacks and their applications.Binary search algorithm, binary trees, binary-search-tree data-structure.Balanced binary-search-tree: Red-Black trees.Hashing for insert, search, delete.Heap data structure.Efficient data structures, apart from those in items 6,7, and 8, for sets with the following group of operations:insert, delete, membership,insert, delete, minimum,union, intersection, dierence,Denition of graphs, paths, trees, cycles. Data structures for graphs: adjacency lists, adjacency matrix.

Graph algorithms: Depth First Search, Breadth First Search, Minimum Spanning Tree.

Text Books:
1. AV Aho, J Hopcroft, JD Ullman, Data Structures and Algorithms, Addison- Wesley, 1983.
2. MT Goodrich, R Tamassia, DM Mount, Data Structures and Algorithms in Java, 5th Ed., Wiley, 2010.

Reference Books:
1. TH Cormen, CF Leiserson, RL Rivest, C Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009.
2. AV Aho, J Hopcroft, JD Ullman, The Design and Analysis of Algorithms, Addison-Wesley, 1974.

2. CSL702 ALGORITHMS 4 CREDITS (3-0-2)
Prerequisite: Programming and Data Structure

Algorithmic paradigms: Dynamic Programming, Greedy, Branch-and-bound;
Sorting and Searching Algorithms: Asymptotic complexity, Amortized analysis;
Graph Algorithms: Shortest paths, Flow networks; NP-completeness; Randomized algorithms; Linear programming; Computational Geometry algorithms: Range searching, Convex hulls;
Polynomial and FFT, PrimarilyTesting,Stringmatching, Approximation algorithms;

Text Books:
1. Cormen,Lierserson, Rivest and Stein, Introduction to Algorithms, PHI, 3rd Edition
2. Horowitz,Sahani, and Rajsekaran Fundamentals of Computer Algorithms, University Press(India), 2008
3.

Reference Books:
1. AnanyLevitin,Introduction to the Design Analysis Of Algorithm
2. Alfred V. Aho,Design& Analysis of Computer Algorithm
3. David E. Goldberg, Genetic Algorithms

3. CSL703 MOBILE AND PERVASIVE COMPUTING 4 CREDITS (3-0-2)
Prerequisite: Computer Architecture & Microprocessors, Computer Networks

Introduction to mobile computing and pervasive/ubiquitous computing, Pervasive computing

systems - HP's Cooltown, Microsoft's EasyLiving.Enabling technologies for mobile and pervasive computing: sensor technology and wireless sensor networks, RFID technology, smartphones. Mobile and pervasive networking: wireless TCP, Mobile IP, ad-hoc routing; data access and management; pervasive computing middleware: AURA, GAIA, ONE.WORLD, service discovery. Context-aware computing: location-aware systems-Active Badge, RADAR, Cricket, GPS; location-aware services; issues and challenges in context awareness. Security and privacy in pervasive and mobile computing environment. Applications: Internet of Things, smart homes/offices, intelligent traffic systems, social computing, wearable computing.

Text Books:

1. Jochen Burkhardt, Pervasive Computing: Technology and Architecture of Mobile Internet Applications 14th Edition, Pearson Education Singapore Pvt. Ltd 2002.
2. Stefan Poslad, Ubiquitous Computing: Smart Devices, Environments And Interactions 1st Edition, 2010, Wiley India Pvt. Ltd.

Reference Book:

1. Laurence T. Yang, Handbook On Mobile And Ubiquitous Computing Status And Perspective, 2012, CRC Press

4. CSL704 INFORMATION THEORY AND CODING 4 CREDITS (3-0-2)
Prerequisite: None

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.

Text Book:

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.

Reference Book:

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

5. CSL705 COMPUTER ARCHITECTURE 4 CREDITS (3-0-2)
Prerequisite: Computer Organization and Architecture

Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors, Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards, Exception handling, Pipeline optimization techniques, Compiler techniques for improving performance. Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies. Instruction-level

parallelism: basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.

Text Books:

1. John L. Hennessy and David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann.
2. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill.

Reference Books:

1. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, TataMcGraw-Hill.
2. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House.

6. CSL706 STATISTICAL ANALYSIS 4 CREDITS (3-0-2)
Prerequisite: None

Statistical data: The statistical method, misuse, misinterpretation and bias, sampling and sample size, data preparation and cleaning, missing data and data errors, statistical error, statistics in medical research. Statistical concepts: Probability theory – odds, risks, Frequentist probability theory, Bayesian probability theory, probability distributions. Statistical modeling, computational statistics, inference, bias, confounding, hypothesis testing, types of error, statistical significance, confidence intervals, power and robustness, degrees of freedom, non-parametric analysis. Descriptive statistics: counts and specific values, measures of central tendency, measures of spread, measures of distribution shape, statistical indices, moments. Key functions and expressions: key functions, measures of complexity and model selection, matrices. Data transformation and standardization: Box-Cox and power transforms, Freeman-Tukey transforms, logit transform, normal transform. Data exploration: Graphics and visualization, exploratory data analysis. Randomness and Randomization: Random numbers, random permutations, resampling, runs test, random walks, Markov processes, Monte Carlo methods. Correlation and autocorrelation: Pearson correlation, Rank correlation, Canonical correlation, Autocorrelation. Probability distribution: Discrete distributions, continuous univariate distributions, Multivariate distributions, kernel density estimation. Estimation and estimators: Maximum Likelihood Estimation(MLE), Bayesian estimation. Classical tests: Goodness of fit tests, Z-tests, T-tests, Variance tests, Wilcoxon rank-sum/Mann-Whitney U test, Sign test. Contingency tables: Chi-square contingency table test, G contingency table test, Fisher's exact test, Measures of association, McNemar's tset. Design of experiments: Completely randomized designs, Randomized block designs, Factorial designs, regression design and response surfaces, Mixture designs. Analysis of variance and covariance: ANOVA, MANOVA, ANCOVA, Non-parametric ANOVA. Time series analusis and temporal autoregression: Moving averages, Trend analysis, ARMA and ARIMA models, Spectral analysis.

Text Books: Dr. M J de Smith, A comprehensive handbook of statistical concepts, techniques and software tools.

Reference Books:

7. CSL707 CRYPTOGRAPHY AND NETWORK SECURITY 4 CREDITS (3-0-2)
Prerequisite: Computer Networks, DISCRETE STRUCTURES, Algorithm

Introduction: Basic objectives of cryptography, secret-key and public-key cryptography, one-way and trapdoor one-way functions, cryptanalysis, attack models, classical cryptography.
Block ciphers: Modes of operation, DES and its variants, RCS, IDEA, SAFER, FEAL, BlowFish, AES, linear and differential cryptanalysis.
Stream ciphers: Stream ciphers based on linear feedback shift registers, SEAL, unconditional security.
Message digest: Properties of hash functions, MD2, MD5 and SHA-1, keyed hash functions, attacks on hash functions.
Public-key parameters: Modular arithmetic, gcd, primality testing, Chinese remainder theorem, modular square roots, finite fields.
Intractable problems: Integer factorization problem, RSA problem, modular square root problem, discrete logarithm problem, Diffie-Hellman problem, known algorithms for solving the intractable problems.
Public-key encryption: RSA, Rabin and EIGamal schemes, side channel attacks. Key exchange: Diffie-Hellman and MQV.
Digital signatures: RSA, DSA and NR signature schemes, blind and undeniable signatures.
Entity authentication: Passwords, challenge-response algorithms, zero-knowledge protocols. Standards: IEEE, RSA and ISO standards.
Security issues: Terminology (Integrity, Availability, Confidentiality, Non-repudiation, Authentication, Authorization/Access Control, accounting, auditing, Passive and Active Attacker, Interruption, Interception, Modification, Fabrication, Social Engineering), Vulnerabilities and Counter Measures (Viruses, worms, Trojan horses, backdoors, unused services, buffer overflows, RPC), Exploits (Buffer overflow, Port Scanning etc).
Network security: Certification, public-key infra-structure (PKI), secure socket layer (SSL), Kerberos, PGP, S/MIME, SSH, SET, IPsec, Kerberos, Firewalls, VPN etc, Secure (commerce) Transaction over a network, Network Anonymity.
Advanced topics: Elliptic and hyper-elliptic curve cryptography, number field sieve, lattices and their applications in cryptography, hidden monomial cryptosystems, cryptographically secure random number generators, Recent trends in cryptography.
Case studies: Installing Unix and common service daemons (Unix Security, Windows NT Security, Ping, traceroute, TCP Dump, sniffer etc.).

Text Books:

1. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press.
2. William Stallings, Cryptography and Network Security: Principles and Practice, Prentice Hall of India.

Reference Books:

1. Neal Koblitz, A course in number theory and cryptography, Springer.
2. Johannes A. Buchmann, Introduction to Cryptography, Undergraduate Text in Mathematics, Springer.
3. B. Schneier, Applied Cryptography, 2nd Ed, John Wiley & Sons, Inc., 1996.
4. C. Kauffman, R. Perham and M. Speciner, Network Security: Private Communication in a Public World, Prentice-Hall, 1994.
5. H. C. A. van Tilborg, Fundamentals of Cryptology, Kluwer Academic Publishers, 2000.
6. P. Garrett, Making and Breaking Codes: An Introduction to Cryptology, Prentice-Hall, 2001.
7. W. Cheswick, S. Bellovin and A. Rubin, Firewalls and Internet Security. Repellingthe Hacker, 2nd Ed. Addison–Wesley, 2003.

8. CSL708 SOFTWARE ENGINEERING 4 CREDITS (3-0-2)
Prerequisite: Software Engineering

Object-oriented methods of information systems analysis and design for organizations with data-processing needs. System feasibility; requirements analysis; database utilization; Unified Modeling Language; software system architecture, design, and implementation, management; project control; and systems-level testing. Analysis patterns, Design patterns. Software testing objectives and principles, Verification vs. Validation, Types of testing, Test tools & Models, Object-oriented Testing, Model Based testing, Test automation. Software Quality Assurance and Quality control, Software Process Control, Quality factors, Quality standards – TQM, ISO, SEI CMM, PCMM, Six sigma, Reliability, Hazard, Availability, Steady State Availability, Estimation of Residual Errors, Reliability Models.

Text Books:

1. Grady Booch. Object Oriented Analysis and Design, Addison-Wesley.
2. Fundamentals of Software Engineering – C. Ghezzi, M. Jazayeri, D. Mandrioli

Reference Books:

1. Grady Booch, James Rumbaugh and Ivar Jacobson. Unified Modeling Language Guide, Addison-Wesley.
2. Erich Gamma et al., Design Patterns: Elements of Reusable OO Software, Addison-Wesley.
3. Michael L. Scott, Programming Language Pragmatics, Morgan-Kaufmann.
4. Bill Venners, Inside the JAVA 2 Virtual Machine, McGraw Hill.
5. Software Engineering – Sommerville, Pearson

9. CSL706 OPTIMIZATION TECHNIQUE 4 CREDITS(3-0-2)
Prerequisite: Linear Programming

Nonlinear programming: Convex sets and convex functions, Kuhn-Tucker conditions. Convex **quadratic programming**: Wolfe's and Pivot complementary algorithms, Separable programming.
Geometric programming: Problems with positive coefficients up to one degree of difficulty, generalized method for the positive and negative coefficients.
Dynamic programming: Discrete and continuous dynamic programming (simple illustrations).
Search Techniques:
One dimensional Search Methods: Unimodal functions, simultaneous uniform search method, Sequential search method, Fibonacci search method, Golden section search method.
Unconstrained Multi-dimensional Search Methods: Univariate search method, Method of steepest descent, Conjugate gradient method, Fletcher Reeves method,
Constrained Multi-dimensional Search Methods: Rosen's Gradient projection method, Penalty function method.

Text Books:

1. Taha H.A. - Operations Research; An Introduction, 7th ed., 2003, MacMillan Publishing Co.
2. Ravindran A., Phillips, D.T., Solberg J.J. - Operations Research : Principles and Practice, 2nd ed.,2001, John Wiley & Sons.

Reference Books:

1. Pant J.C. - Introduction to Optimization techniques (Operations Research), 6th ed., 2005, Jain Brothers, New Delhi.
2. Hillier F.S., Lieberman G.J. - Introduction to Operations Research, 7th ed.,2002,Tata McGraw - Hill publishing Company Limited New Delhi.

List of Electives

1. **CSL711 AD-HOC AND WIRELESS NETWORKS 4 CREDITS (3-0-2)**
   Prerequisite:Computer Networks

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; Multi cast 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.

Text Books:

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.

Reference Books:

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 Newtorks from Theory to Reality, Nova Science Publishers, 2008

2. **CSL712 AUTOMATA THEORY 4 CREDITS (3-0-2)**
   Prerequisite: Logic for Computer Science

Automata and Logical specification: MSO logic over words, The equivalence theorem, consequences and applications in model checking, FO and MSO definability. Congruence's and minimization: homomorphism's, quotients, and abstraction; minimization and equivalence of DFAs;

equivalence andreduction of NFAs. Tree automata: trees and tree languages; deterministic tree automata, nondeterministic tree automata, emptiness, congruence and minimization; logic oriented formalisms over trees; applications, Pushdown and counter systems communicating systems,Petri nets.

Text Books:

1. Thomas, W. "Applied Automata Theory". Springer 2005
2. Pin, J. "Mathematical foundations of automata theory." Springer 2012

3. **CSL713 MICROPROCESSOR BASED SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Microprocessors and Interfacing, Computer Organization and Architecture

Introduction: Basics of Von Neumann Architecture and the early Microprocessors, CISC and RISC concepts; Parallelism in Processor Architecture: Pipelining, Super-scalar, Super-pipeline and VLIW Architectures, Low-power Architecture; Built-in Multiprocessing support; Co-processors; Processor Architecture with hierarchical memory organization: Cache memory, Virtual memory; Built-in Multi-user and multitasking support in 16-bit and 32-bit microprocessors, Built-in memory mapping and management support; Evolution of platform architecture; Special-purpose processor Architectures: Signal processing Microprocessors; Communication processors; Case studies with contemporary Microprocessors.

Text Books:

1. Ram Badri, Advanced Microprocessor & Interfacing
2. David J. Comer, Microprocessor based System Design

Reference Books:

1. Nikitas A. Alexandridis, Design of microprocessor-based systems, PHI.
2. Mohamed Rafiquzzaman,Microprocessors and Microcomputer-Based System Design, CRC Press.

4. **CSL714 OPERATING SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Operating Systems

Theory and implementation aspects of distributed operating systems, Process synchronization in multiprocessing/multiprogramming systems. Inter-process communication and co-ordination in large distributed systems,Distributed resource management, Fundamentals of real time operating systems.Case studies. Information management in distributed systems: security, integrity and concurrency problems. Fault tolerance issues. OS issues related to the Internet, intranets, pervasive computing, embedded systems, mobile systems and wireless networks. Case studies of contemporary operating systems.

Text Books:

1. Andrew S. Tanenbaum, Herbert Bos, Modern Operating Systems, 4th Edition, Pearson Education.
2. Silberschatz and Galvin, Operating Systems Concepts, 7th Edition, Wiley & sons.

Reference Books:

1. Chow. Distributed Operating Systems And Algorithm Analysis, Pearson Education India, 2009.
2. Wiseman, Yair. Advanced Operating Systems and Kernel Applications: Techniques and

Technologies: Techniques and Technologies, IGI Global, 2009.

5. **CSL715 COMPILER CONSTRUCTION 4 CREDITS (3-0-2)**
Prerequisite: Compiler Design

Review of compiler fundamentals - lexical analysis, parsing, semantic analysis, error recovery and intermediate code generation; Runtime storage management; Code generation; Code improvement - peephole optimization, dependence analysis and redundancy elimination, loop optimization, procedural and inter-procedural optimization, instruction scheduling, Parallelism detection: Data dependence, control dependence, various restructuring transformations on loops. Inter-procedural analysis: Constant propagation, data dependence etc. optimization for memory hierarchy; Compilation for high performance architecture; Portability and retarget ability; Selected topics from compilers for imperative, object-oriented and mark-up languages, parallel and distributed programming and concurrency.Selected case studies.

Text Books:

1. Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques and Tools, Addison-Wesley.
2. Michael L. Scott, Programming Language Pragmatics, Elsevier.

Reference Books:

1. Andrew W. Appel, Modern Compiler Implementation in C/Java, Cambridge University Press.
2. Keith D. Cooper and Linda Torczon, Engineering a Compiler, Elsevier.
3. Allen I. Holob, Compiler Design in C, Prentice-Hall.
4. Steven S. Muchnik, Advanced Compiler Design and Implementation, Elsevier.
5. Randy Allen and Ken Kennedy, Optimizing Compilers for Modern Architectures, Elsevier.

6. **CSL716 COMPUTER NETWORK 4 CREDITS (3-0-2)**
Prerequisite: Computer Networks

Introduction: Overview of computer networks, seven-layer architecture, TCP/IP suite of protocols, etc.MAC protocols for high-speed LANS, MANs, and wireless LANs. (For example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wireless Ethernet, etc.)Fast access technologies. (For example, ADSL, Cable Modem, etc.)
IPv6: Why IPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbour discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6.6bone.Mobility in networks. Mobile IP. Security related issues. IP Multicasting, Multicast routing protocols, address assignments, session discovery, etc. TCP extensions for high-speed networks, transaction-oriented applications, other new options in TCP. Network security at various layers, Secure-HTTP, SSL, ESP, Authentication header, Key distribution protocols. Digital signatures, digital certificates.

Text Books:

1. W. R. Stevens. TCP/IP Illustrated, Volume 1: The protocols, 2nd Edition, Addison Wesley, 2011.
2. G. R. Wright.TCP/IP Illustrated, Volume 2: The Implementation,Addison Wesley, 1995.
3. W. R. Stevens.TCP/IP Illustrated, Volume 3: TCP for Transactions, HTTP, NNTP, and the

Unix Domain Protocols, Addison Wesley, 1996.

Reference Books:

1. R. Handel, M. N. Huber, and S. Schroeder.ATM Networks: Concepts, Protocols, Applications,Addison Wesley, 1998.
2. W. Stallings.Cryptography and Network Security: Principles and Practice, 2nd Edition, Prentice Hall, 1998.
3. C. E. Perkins, B. Woolf, and S. R. Alpert.Mobile IP: Design Principles and Practices,Addison Wesley, 1997.

7. **CSL717 DATABASE MANAGEMENT SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Database Management Systems

Review of DBMS concepts; Relational database systems, applications of DBMS. Transactions &Serializability: Concurrent executions, Serializability View and conflict serializability, Recoverability. Concurrency Control: Lock based protocols, timestamp based protocols, validation based protocols, deadlock handling, insert and delete operations. Recovery System: Failure classification, recovery and atomicity, log based recovery, shadow paging, buffer management, remote backup systems. Distributed Databases: Homogeneous and heterogeneous databases, distributed transactions, commit protocols, concurrency control in distributed databases.Advanced Data Types: Time in databases, spatial and geographic databases, multimedia databases. Advanced applications : Knowledge discovery and data mining, data mining functionalities, classification of data mining systems, data warehousing concepts, slicing, dicing, schemas, data warehouse architecture, introduction to Data Mining Query Language (DMQL). Study of typical DBMS packages.

Text Books:

1. Silberchatz, A., Korth, H. F. and Sudarshan, S., “Database System Concepts”, 6th Ed., Tata-McGraw Hill. 2010
2. Han, J. and Kamber, M., “Data Mining: Concepts and Techniques”, 2nd Ed., Morgan Kaufmann. 2006

Reference Books:

1. Ray Chhanda, “Distributed Database Systems”, Pearson. 2009
2. Date, C. J, “An Introduction to Database Systems”, 8th Ed., Pearson. 2008

8. **CSL718 ARTIFICIAL INTELLIGENCE 4 CREDITS (3-0-2)**
Prerequisite: Data Structure

Problem solving by search: state space, problem reduction, game playing, constraint satisfaction; Automated Reasoning: proposition and first order logic, inference and deduction, resolution refutation, answer extraction, knowledge based systems, logic programming and constrained logic programming, non-monotonic reasoning; Planning: state-space, plan space and partial order planning, planning algorithms; Reasoning under Uncertainty: probabilistic reasoning, belief networks; Learning: inductive learning, decision trees, logical approaches, computational learning theory, Neural networks, reinforcement learning; Intelligent Agents; Natural Language Understanding; Applications.

Text Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall.

2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents

Reference Books:

1. Nils J. Nilsson, Artificial Intelligence: A New Sythesis, Morgan-Kaufmann.
2. Mishra, R. B., Artificial Intelligence, PHI Pub.
3. Nilsson N J, Principles of Artificial Intelligence
4. Stuart Russell, Artificial Intelligence, Pearson Pub.

9. **CSL719 BIOINFORMATICS 4 CREDITS (3-0-2)**

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.

Text Books:

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

Reference Books:

1. S. L. Salzberg, D. B. Searls and S.Kasifeds, 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.

10. **CSL720 BIOMETRIC SECURITY 4 CREDITS (3-0-2)**

Prerequisite: Network Security

Security via biometrics, space domain based biometrics and recognition techniques. Correlation based biometric filters, Basic theory of correlation filters, Face Iris Fingerprint biometrics, Biometric fusion, 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.

Text Books:

1. J. D. Woodward, N.M.Orlans, P.T.Higgins, Biometrics, Dreamtech Publishers.
2. P.Reid, Biometrics for Network Security, Pearson Press.
3. A.K. Jain, P. Flynn, and A. Ross. Handbook of Biometrics. Springer, 2008. ISBN : 978-0-387-71040-2.

Reference Book:

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

11. **CSL721 CLUSTER AND GRID COMPUTING 4 CREDITS (3-0-2)**

Prerequisite: Computer Networks

Introduction to high performance computing, basic definitions: cluster, grid, meta-computing, middleware etc., examples of representative applications. Programming models: shared memory, message passing, peer-to-peer, broker-based. Introduction to PVM and MPI.Architecture of cluster-based systems. Issues in cluster design: performance, single-system image, fault tolerance, manageability, programmability, load balancing, security, storage. Architecture of Grid systems.Grid security infrastructure. Examples of Grids: Globus etc.

Text Books:

1. C.S.R.Prabhu, Grid and Cluster Computing, Prentice-Hall India Private Limited,2008
2. Mark Baker, RajkumarBuyya and Dan Hyde, Cluster Computing: A High-Performance Contender, IEEE Computer, July 1999.

Reference Books:

a. B. Wilkinson and M. Allen, Parallel Programming Techniques and Applications using Networked Workstations and Parallel Computers, 1999

12. **CSL722 CLOUD COMPUTING 4 CREDITS (3-0-2)**
Prerequisite: Computer Networks

Introduction: Distributed Computing and Enabling Technologies, Cloud Fundamentals: Cloud Definition, Evolution, Architecture, Applications, deployment models, and service models. Virtualization: Issues with virtualization, virtualization technologies and architectures, Internals of virtual machine monitors/hypervisors, virtualization of data centers, and Issues with Multi-tenancy. Implementation: Study of Cloud computing Systems like Amazon EC2 and S3, Google App Engine, and Microsoft Azure, Build Private/Hybrid Cloud using open source tools, Deployment of Web Services from Inside and Outside a Cloud Architecture. MapReduce and its extensions to Cloud Computing, HDFS, and GFS. Interoperability and Service Monitoring: Issues with interoperability, Vendor lock-in, Interoperability approaches. SLA Management, Metering Issues, and Report generation. Resource Management and Load Balancing: Distributed Management of Virtual Infrastructures, Server consolidation, Dynamic provisioning and resource management, Resource Optimization, Resource dynamic reconfiguration, Scheduling Techniques for Advance Reservation, Capacity Management to meet SLA Requirements, and Load Balancing, various load balancing techniques. Migration and Fault Tolerance: Broad Aspects of Migration into Cloud, Migration of virtual Machines and techniques. Fault Tolerance Mechanisms. Security: Vulnerability Issues and Security Threats, Application-level Security, Data level Security, and Virtual Machine level Security, Infrastructure Security, and Multi-tenancy Issues. IDS: host-based and network-based, Security-as-a-Service. Trust Management, Identity Management, and Access Controls Techniques. Advances: Grid of Clouds, Green Cloud, Mobile Cloud Computing

Text Books:

1. Cloud Computing Principles and Paradigms, RajkumarBuyya, James Broberg, AndrzejGoscinski, Wiley Publishers 2011
2. Cloud Computing Bible, Barrie Sosinsky, Wiley Publishers 2010

Reference Books:

1. Cloud Computing : Web-based Applications that change the way you work and collaborate online, Michael Miller, Pearson Education 2008
2. Mastering Cloud computing, RajkumarBuyya, Christian Vacchiola, S ThamaraiSelvi, McGraw Hill 2013
3. Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide, David S. Linthicum 2010
4. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, SubraKumaraswamy, ShahedLatif, O'Reilly 2010
5. Cloud Computing : A Practical Approach, Toby Velte, Antohy T Velte, Robert Elsenpeter, McGraw Hill 2009

13. **CSL723 COMBINATORIAL OPTIMIZATION 4 CREDITS (3-0-2)**
Prerequisite: Algorithms

Optimization Problem: Global and Local optima; Convex sets and functions; Convex programing 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.

Text Book:

1. C. H. Papadimitriou, K. Steiglitz, Combinatorial optimization: algorithm and Complexity, Prentice Hall of India, 2006.

Reference Books:

1. C. H. Papadimitriou, Computational Complexity, Addison Wesley, 1st ed. 2002.
2. D. Knuth, Art of Computer Programming, Vol. IV, Addison Wesley, 1st ed. 2008.

14. **CSL724 COMPLEX NETWORKS 4 CREDITS (3-0-2)**
Prerequisite: Programming and Data Structures, Algorithm

Objectives, Study of the models and behaviors of networked systems, Empirical studies of social, biological, technological and information networks. Exploring the concepts of small world effect, degree distribution, clustering, network correlations, random graphs, models of network growth, and preferential attachment and dynamical processes taking place on networks. Content Types of network: Social networks, Information networks, Technological networks, Biological networks. Properties of network: Small world effect, transitivity and clustering, degree distribution, scale free networks, maximum degree; network resilience; mixing patterns; degree correlations; community structures; network navigation. Random Graphs: Poisson random graphs, generalized random graphs, the configuration model, power-law degree distribution, directed graph, bipartite graph, degree correlations. Models of network growth: Prices model, Barabasi and Alberts model, other growth models, vertex copying models. Processes taking place on networks: Percolation theory and network resilience, Epidemiological processes. Applications: Search on networks, exhaustive network search, guided network search, network navigation; network visualization.

Text Books:

1. S. N. Dorogovtsev and J. F. F. Mendes, Evolution of Networks, Oxford University Press.
2. NarsinghDeo, Graph Theory, Prentice Hall of India.

Reference Books:

1. Maarten van Steen, Graph Theory and Complex Networks: An Introduction
2. Ernesto Estrada, The Structure of Complex Networks: Theory and Applications
3. D. Ganesh Rao, K. ChannaVenkatesh, Network Theory, Pearson Pub.

15. **CSL725 COMPUTATIONAL COMPLEXITY 4 CREDITS (3-0-2)**
Prerequisite: ALGORITHMS

Computational Models (machine models, logic); Problems, computability, Algorithms, Resources, and Complexity; Turing machines (time and space bounds, non-determinism); Logic (Boolean logic, circuits, first and second order logic); Complexity classes (hierarchy theorem, reachability, P, NP, Co-NP); Reduction and completeness; Randomized computation; Approximability; Cryptography and protocols; Parallel Computation; Polynomial Hierarchy; Logarithmic space; Polynomial space; Exponential time and space.

Text Books:

1. Christos H. Papadimitriou, Computational Complexity, Addison-Wesley Longman.
2. Michael Sipser, Introduction to the Theory of Computation, PWS Publishing.

Reference Books:

1. John E. Hopcroft and Jeffrey D. Ullman, Introduction to Automata, Languages and Computation, Addison-Wesley, 1979.
2. J. Balcazar, J. Diaz, and J. Gabarro, Structural Complexity, Volumes I and II, Springer.

16. **CSL726 COMPUTATIONAL GEOMETRY 4 CREDITS (3-0-2)**
Prerequisite: Design and Analysis of Algorithms

Introduction: historical perspective, geometric preliminaries. Convex hulls algorithms in 2d and 3d, lower bounds. Triangulations: polygon triangulations, representations, point-set triangulations. Voronoi diagrams: algorithms, closest pair problems. Delayney triangulations: algorithms (divide-and-conquer, flip, incremental), duality of Voronoi diagrams, properties (min-max angle). Geometric searching: point-location, 2d linear programming with prune and search. Visibility: algorithms for weak and strong visibility, visibility with reflections, art-gallery problems. Arrangements of lines: 2d arrangements, zone theorem, many-faces complexity, algorithms. Sweep techniques: plane sweep for segment intersections, Fortune s sweep for Voronoi diagrams, topological sweep for line arrangements. Combinatorial geometry: Ham-sandwich cuts, Helly s theorems, k-sets. Rectilinear geometry: intersection and union of rectangles, rectangle searching. Robust geometric computing.Applications of computational geometry.

Text Book:
1. Mark de Berg, Otfried Schwarzkopf, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer.

Reference Books:
1. F. P. Preparata and Michael I. Shamos, Computational Geometry: An Introduction, Springer.
2. Joseph O Rourke, Computational Geometry in C, Cambridge University Press.4.Lecture Notes by David Mount.

17. **CSL727 COMPUTATIONAL NUMBER THEORY 4 CREDITS (3-0-2)**
Prerequisite: None

Algorithms for integer arithmetic: Divisibility, gcd, modular arithmetic, modular exponentiation, Montgomery arithmetic, congruence, Chinese remainder theorem, Hensel lifting, orders and primitive roots, quadratic residues, integer and modular square roots, prime number theorem, continued fractions and rational approximations.
Representation of finite fields: Prime and extension fields, representation of extension fields, polynomial basis, primitive elements, normal basis, optimal normal basis, irreducible polynomials.
Algorithms for polynomials: Root-finding and factorization, Lenstra-Lenstra-Lovasz algorithm, polynomials over finite fields.
Elliptic curves: The elliptic curve group, elliptic curves over finite fields, Schoof's point counting algorithm.
Primality testing algorithms: Fermat test, Miller-Rabin test, Solovay–Strassen test, AKS test.
Integer factoring algorithms: Trial division, Pollard rho method, p-1 method, CFRAC method, quadratic sieve method, elliptic curve method.
Computing discrete logarithms over finite fields: Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method, index calculus methods, linear sieve method, Coppersmith's algorithm.
Applications: Algebraic coding theory, cryptography.

Text Books:
1. Victor Shoup, A Computational Introduction to Number Theory and Algebra, Cambridge University Press.
2. Henri Cohen, A Course in Computational Algebraic Number Theory, Springer-Verlag.

Reference Books:

1. Maurice Mignotte, Mathematics for Computer Algebra, Springer-Verlag.
2. Ivan Niven, Herbert S. Zuckerman and H. L. Montgomery, An Introduction to the Theory of Numbers, John Wiley.
3. Joachim von zurGathen and Juergen Gerhard, Modern Computer Algebra, Cambridge University Press.
4. Rudolf Lidl and HaraldNiederreiter, Introduction to Finite Fields and their Applications, Cambridge University Press.
5. Alfred J. Menezes, editor, Applications of Finite Fields, Kluwer Academic Publishers.
6. Joseph H. Silverman and John Tate, Rational Points on Elliptic Curves, Springer International Edition.
7. D. R. Hankerson, A. J. Menezes and S. A. Vanstone, Guide to Elliptic Curve Cryptography, Springer-Verlag.

18. **CSL728 COMPUTER VISION 4 CREDITS (3-0-2)**
Prerequisite: DISCRETE STRUCTURES

Discrete Geometry and Quantization, Length Estimations, Automated Visual Inspection, Object reorganizationand matching, Depth perception problems, Stereo Geometry and correspondence, Motion analysis, Optical-flow, Multi-resolution Processing of Images, Applications of Computer Vision, Remote Sensing, BiomedicalImaging, Document Processing, Target tracking.

Text Books:

1. D.A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2003.
2. L.G. Shapiro, G. C. Stockman, Computer Vision, Prentice Hall, 2001.

Reference Books:

1. M. Sonka, V. Hlavac, R. Boyle, Image Processing, Analysis, and Machine Vision, Cengage Learning, 2008.
2. T. Morris, Computer Vision and Image Processing, Palgrave McMillan, 2003.

19. **CSL729 DATA MINING AND DATA WAREHOUSING 4 CREDITS (3-0-2)**
Prerequisite: Data Structure

Data warehousing, OLAP and Data mining, Classification of data mining techniques, Discovery and analysis of patterns, trends, and deviations, Data mining models: decision trees, genetic algorithms, neural nets, etc. Clustering, Enabling data mining through data warehouse.Data marts, Multidimensional databases, Data mining applications.

Text Books:

1. Adriaans, P. (1996). Data mining. Addison- Wesley
2. Jiawei Han and MichelineKamber, “Data Mining: Concepts and. Techniques”, Second Edition, 2006

Reference Books:

1. Margaret Dunham, Data Mining: Introductory and Advanced Topics, Published by Prentice Hall
2. Weiss, Sholom M. - Predictive data Mining: a practical guide / Sholom M. Weiss, NitinIndurkhy. - San Francisco, Calif. : Morgan Kaufmann Publishers, 1998 - 1558604030

20. **CSL730 DIGITAL IMAGE PROCESSING 4 CREDITS (3-0-2)**
Prerequisite: Signals and Systems

Sensor and Imaging: Imaging Optics, Radiometry of Imaging, Illumination sources and techniques, Camera Principles, Color Imaging, Single Sensor Color Imaging and Color Demos icing, Range

Images, 3D Imaging. Signal Representation: Vector Space and Unitary Transforms, Multi-Resolutional Signal Representation, Wavelet Decomposition, Scale space and diffusion, Representation of color, Retinex Processing, Markov Random Field Modeling of Images. Non-linear Image Processing: Median and Order Statistics Filters, Rank-Ordered-Mean Filters and Signal Dependent Rank-Ordered-Mean Filters, Two Dimensional Teager Filters, Applications of nonlinear filters in image enhancement, edge detections, noise removal etc. Feature Estimation: Morphological Operations, Edge Detection, Edges in multichannel images, Texture Analysis, Optical flow based motion estimation, Reflectance based shape recovery, Depth from focus, Stereo matching and depth estimation. Image and Video Compression Standards: Lossy and lossless compression schemes: Transform Based, Sub-band Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG-1, MPEG-4, and MPEG-7. Object Analysis, Classification: Bayesian Classification, Fuzzy Classification, Neural Network Classifiers, shape Reconstruction from volumetric data, and knowledge-based interpretation of images.

Text Books:

1. Rafael C Gonzalez and Richard E Woods,Digital Image Processing, 3rd Edition, Pearson Education.
2. Burger, Wilhelm, Burge, Mark J., Principles of Digital Image Processing - Advanced Methods, Springer

Reference Books:

1. Wilhelm Burger, Mark J. Burge, Principles of Digital Image Processing: Core Algorithms, Springer.
2. Chris Solomon and Toby Breckon, Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab.
3. Jayaraman, Digital Image Processing, Tata McGraw-Hill Education, 2011
4. Milan Sonka, Vaclav Hlavac, Roger Boyle, Digital Image Processing and Computer Vision

21. **CSL731 DIGITAL SIGNAL PROCESSING 4 CREDITS (3-0-2)**
Prerequisite: Signals and Systems

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.

Text Books:

1. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing:Principles, Algorithms and Applications, Pearson Pub.
2. Johnson, Introduction to Digital Signal Processing, PHI

Reference Books:

1. Monson Hayes, Digital Signal Processing, 2nd Edition,Schaum's Series
2. Richard G Lyons, Understanding Digital Signal Processing, Pearson Education.

22. **CSL732 DISCRETE STRUCTURES 4 CREDITS (3-0-2)**
Prerequisite: None

Propositional Logic, Proof Methods of Implications, Sets, Basic operations on sets, Functions, Relations, Binary relations: Equivalence Relations, Partial Orders and Posets. Mathematical Induction, Pigeonhole Principle, First Order Logic and Other Proof Methods.Cardinality of sets, Finite and Infinite Sets, Countable and Uncountable Sets, Cantors Theorem. Algebraic Structures: Semigroups, Monoids, Groups, Substructures and Morphisms, Rings, Fields and Vector Spaces; Lattices, Boolean Algebras, Morphisms of Boolean Algebras; Basic Counting Principles, Permutations, Combinations, Recurrence Relations and their solutions.

Text Books:

1. C.L.Liu, Elements of Discrete Mathematics, second edition 1985, McGraw-Hill Book Company. Reprinted 2000.
2. K.H.Rosen, Discrete Mathematics and applications, fifth edition 2003, TataMcGraw Hill publishing Company.

Reference Books:

1. J .L.Mott, A.Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists and Mathematicians, second edition 1986, Prentice Hall of India.
2. W.K.Grassmann and J.P.Trembnlay, Logic and Discrete Mathematics, A Computer Science

23. **CSL733 DISTRIBUTED SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: None

Basic concepts. Models of computation: shared memory and message passing systems, synchronous and asynchronous systems. Logical time and event ordering. Global state and snapshot algorithms, mutual exclusion, clock synchronization, leader election, deadlock detection, termination detection, spanning tree construction. Programming models: remote procedure calls, distributed shared memory. Fault tolerance and recovery: basic concepts, fault models, agreement problems and its applications, commit protocols, voting protocols, check pointing and recovery, reliable communication. Distributed file servers: Concurrency control and recovery, resiliency etc. Security and Authentication: basic concepts, Kerberos. Resource sharing and load balancing. Special topics: distributed objects, distributed databases, directory services, webservices, Selected case studies.

Text Books:

1. MukeshSinghal and NiranjanShivaratri, Advanced Concepts in Operating Systems, McGraw-Hill.
2. Andrew S. Tanenbaum, Distributed Operating Systems, ACM Press.

Reference Books:

1. Nancy Lynch, Distributed Algorithms, Morgan Kaufmann.
2. Jie Wu, Distributed Systems, CRC Press.
3. HagitAttiya, Jennifer Welch, Distributed Computing: Fundamentals, Simulations and Advanced Topics, McGraw-Hill
4. SapeMullender (ed.), Distributed Systems, Addison Wesley.
5. G. F. Coulouris, J. Dollimore and T. Kindberg, Distributed Systems: Concepts and Design, 4th Ed, Addison-Wesley, 2005.

24. **CSL734 E- COMMERCE 4 CREDITS (3-0-2)**
Prerequisite: None

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 Web Pages, 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 Web Pages, 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.

Text Books:

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

Reference Book:

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.

25. **CSL735 Embedded Systems 4 CREDITS (3-0-2)**

Prerequisite: Computer Organization and Architecture

Introduction to Embedded Systems - definitions and constraints; hardware and processor requirements; special purpose processors; input-output design and I/O communication protocols; design space exploration for constraint satisfaction; co-design approach; example system design; Formal approach to specification; specification languages; specification refinement and design; design validation; Real Time operating system issues with respect to embedded system applications; time constraints and performance analysis.

Text Books:

3. Raj Kamal, Embedded Systems: Architecture, Programming and Design,Tata McGraw-Hill Education, 2008
4. SantanuChattopadhyay, Embedded System Design, 2nd Edition, PHI
5. Shibu, Introduction to Embedded Systems

Reference Books:

1. Jack G. Ganssle, Embedded Systems
2. Tammy Noergaard, Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmer.
3. Oliver Bailey, Embedded Systems: Desktop Integration

26. **CSL736 FAULT TOLERANT SYSTEMS 4 CREDITS (3-0-2)**

Prerequisite: None

Fundamental concepts in the theory of reliable computer systems design. Introduction to redundancy theory, limit theorems; decision theory in redundant systems. Hardware fault tolerance, redundancy techniques, detection of faults, replication and compression techniques, self-repairing techniques, concentrated and distributed voters, models of fault tolerant computing systems.Case studies. Software fault tolerance: fault tolerance versus fault intolerance, errors and their management strategies. Implementation techniques: software defense, protective redundancy, architectural support. Fault recovery techniques. Coding theory: application to fault tolerant system design. Fault tolerance and reliability of multicomputer networks (direct and indirect) including fault-tolerant routing and sparing techniques. Yield and reliability enhancement techniques for VLSI/WSI array processors.

Text Books:

1. Israel Koren, C. Mani Krishna. Fault-Tolerant Systems. Morgan Kaufmann, 19-Jul-2010.
2. PankajJalote Fault Tolerance in Distributed Systems PTR Prentice Hall, 1994

Reference Books:

a. NoervaagKjetil, An Introduction to Fault-Tolerant Systems
b. Dhiraj K. Pradhan, Fault Tolerant Computer System Design, PHI
c. Robert Hanmer, Patterns for Fault Tolerant Software, Wiley Software Series.

27. **CSL737 FORMAL METHODS AND SOFTWARE VERIFICATION 4 CREDITS (3-0-2)**
Prerequisite: None

Temporal logics: syntax and semantics of temporal logics PLTL, CTL, and CTL*. Model checking: Model checking CTL, PLTL, state explosion problem. Symbolic model checking: binary decision diagrams (BDDs), representing automata by BDDs, BDD based model checking. Reachability properties: Safety properties, Liveness properties, deadlock freeness. Fairness properties: PLTL, CTL. SMV: symbolic model checker. SPIN: model checker based on communicating automata.

Text Books:

3. Berard, B. Bidoit, M. Finkel, A. Laroussine, F. Petit, A. Petrucci, L. Schnoebelen, Ph. And McKenzie, P. Systems and Software verification, Springer. 2001

4. Huth, M. and Ryan, M., "Logic in Computer Science: Modeling and Reasoning About Systems", Cambridge University Press.

28. **CSL738 GAME THEORY 4 CREDITS (3-0-2)**
Prerequisite: None

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, Inter-domain 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.

Text Books:

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.

Reference Books:

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.

29. **CSL739 GRAPH THEORY AND NETWORK ALGORITHMS 4 CREDITS (3-0-2)**

Prerequisite: discrete Mathematics

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.

Text Books:

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

Reference Books:

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.

30. **CSL740 INFORMATION RETRIEVAL 4 CREDITS (3-0-2)**
Prerequisite: None

Introduction to Information Retrieval: The nature of unstructured and semi structured text. Inverted index and Boolean queries. Text Indexing, Storage and Compression: Text encoding: tokenization, stemming, stop words, phrases, index optimization. Index compression: lexicon compression and postings. Lists compression.Gap encoding, gamma codes, Zipfs Law.Index construction. Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes, real-world issues. Retrieval Models: Boolean, vector space, TFIDF, Okapi, probabilistic, language modeling, latent semantic indexing. Vector space scoring.The cosine measure.Efficiency considerations.Document length normalization.Relevance feedback and query expansion.Rocchio. Performance Evaluation: Evaluating search engines. User happiness, precision, recall, F measure. Creating test collections: kappa measure, inter-judge agreement. Text Categorization and Filtering: Introduction to text classification. Naive Bayes models. Spam filtering. Vector space classification using hyper planes; centroids; k Nearest Neighbors. Support vector machine classifiers. Kernel functions. Boosting .Text Clustering: Clustering versus classification. Partitioning methods.k-means clustering. Mixture of Gaussians model.Hierarchical agglomerative clustering.Clustering terms using documents. Advanced Topics: Summarization, Topic detection and tracking, Personalization, Question answering, Cross language information retrieval Web Information Retrieval: Hypertext, web crawling, search engines, ranking, link analysis, PageRank, HITS, XML and Semantic web.

Text Books:

1. Manning, Raghavan and Schutze, Introduction to Information Retrieval, Cambridge University Press.
2. Gerald J. Kowalski Information Retrieval System, Springer US, 23-Aug-2007

Reference Books:

1. Baeza-Yates and Ribeiro-Neto, Modern Information Retrieval, AddisonWesley.
2. SoumenCharabarti, Mining the Web, Morgan-Kaufmann.
3. Survey by Ed Greengrass available in the Internet.

31. **CSL741 INTELLIGENT SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: ALGORITHMS

Data, information and knowledge, Model of an intelligent system. Models of knowledge representations: Representation and reasoning in logic. Semantic representations: semantic networks, frames; Frame/script systems; Conceptual dependency and conceptual graphs. Ontologies. Knowledge based systems: Software architecture of a knowledge-based system, Rule-based programming and production systems, Rule chaining and inference control, Inference: reasoning about knowledge, Temporal reasoning, Inference under uncertainty: Bayesian techniques, Fuzzy reasoning, Case-based reasoning. Intelligent agents, The agent metaphor and attributes of agent-hood, Agent theory and languages, Inter-agent communication, Ontological issues. Alternatives to the symbolic approach: Foundations of connectionist networks; their history. Applications of AI: Example application domains, e.g. Configuration, Diagnosis, Planning, intelligent interfaces, user modeling, practical implications of choosing and applying AI solutions. Knowledge representation and the Web, Semantic Web.

Text Books:

1. Stanislaw H. Zak, Systems and Control, Oxford University Press, 2003
2. E. Reiter and R. Dale, Building Natural Language Generation Systems, Cambridge University Press, 2000.

Reference Book:

1. A.S. Poznyak, E. N. Sanchez and Wen Yu, Differential Neural Networks for Robust Nonlinear Control,World Scientific, 2001.
2. Kevin M. Passino and Stephen Yurkovich, Fuzzy Control, Addison Wesley Longman, Menlo Park, CA, 1998.

32. **CSL742 INTRUSION DETECTION SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Design and Analysis of Algorithms

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.

Text Books:

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

Reference Book:

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

33. **CSL743 LOGIC AND AUTOMATED REASONING 4 CREDITS (3-0-2)**
Prerequisite: None

Propositional Logic: syntax, semantics, soundness and completeness theorems. Boolean satisfiability problem (SAT): normal forms, Horn clauses, resolution principle, DPLL algorithm, recent SAT solvers. First-order Logic: syntax, semantics, soundness and completeness theorems. Higher-order Logic (HOL): syntax, semantics, and types. Automated theorem proving: First-order theorem proving, unification, term rewriting. Theorem provers for HOL: Isabelle/Coq.

Text Books:

1. Huth, M. and Ryan, M., "Logic in Computer Science: Modeling and Reasoning About Systems", Cambridge University Press. 2005
2. Nipkow, T. Paulson, L. Wenzel, M. "Isabelle/HOL a proof assistant for higher-order logic." 2002

34. **CSL744 MACHINE LEARNING 4 CREDITS (3-0-2)**
Prerequisite: ARTIFICIAL INTELLIGENCE

Introduction: Machine learning applications, concepts learning. Introduction to Bayesian learning theory: regression, feature selection, supervised learning, class conditional probability distributions, Examples of classifiers Bayes optimal classifier and error, learning classification approaches, handling continuous attributes. Decision tree learning algorithms: Inference model, general domains, symbolic decision trees, consistency, learning trees from training examples, entropy, mutual information, ID3 algorithm criterion, C4.5 algorithm, handling continuous and missing attributes, confidence, overfitting, pruning, learning with incomplete data. Artificial Neural Network: Single layer neural network, linear reparability, general gradient descent, perceptron learning algorithm, multi-Layer perceptron: two-layers universal approximators, backpropagation learning, important parameters, Margin of a classifier, dual perceptron algorithm, learning nonlinear hypotheses with perceptron. Instance-based Learning: Nearest neighbor classification, k-nearest neighbor, nearest neighbor error probability. Machine learning concepts and limitations: Learning theory, formal model of the learnable, sample complexity, learning in zero-bayes and realizable case, VC-dimension, fundamental algorithm independent concepts, hypothesis class, target class, inductive bias, occam's razor, empirical risk, limitations of inference machines, approximation and estimation errors, Tradeoff. Support Vector Machine (SVM): Kernel functions, implicit non-linear feature space, theory, zero-Bayes, realizable infinite hypothesis class, finite covering, margin-based bounds on risk, maximal margin classifier. Machine learning assessment and Improvement: Statistical model selection, structural risk minimization, bootstrapping, bagging, boosting. Unsupervised learning: introduction, K- means clustering, Hierarchical clustering. Semi-supervised learning: introduction, self-training, co-training.

Text Books:

1. T. M. Mitchell, Machine Learning, McGraw-Hill, 1997.
2. E. Alpaydin, Introduction to Machine Learning, Prentice Hall of India, 2006.

Reference Books:

1. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
2. R. O. Duda, P. E. Hart, and D.G. Stork, Pattern Classification, John Wiley and Sons, 2001.
3. Vladimir N. Vapnik, Statistical Learning Theory, John Wiley and Sons, 1998.
4. Shawe-Taylor J. and Cristianini N., Cambridge, Introduction to Support Vector Machines, University Press, 2000.

35. **CSL745 Medical Image Analysis 4 CREDITS (3-0-2)**
Prerequisite: None

Medical image formation, reconstruction mathematics (Fourier slice theorem, Abel, Hankel and Radon transforms), Compressed Sensing (MRI/CT), PDE-based denoising, active 2D/3D models and segmentation, segmentation via Bayesian estimation, shape priors, Image matching/registration with application to uniand multi-modal co-registration, diffusion MRI analysis, shape/image classification.

Text Books:

1. Medical Imaging Signals and Systems, by Jerry Prince & Jonathan Links, Publisher: Prentice Hall.
2. Digital Image Processing, by Rosenfeld and Kak (Vol. 1); Publisher: Academic Press.

Reference Book:

1. The Fourier Transform and its Applications, by Bracewell, McGraw Hill.
2. Level-set Methods, by J. A. Sethian, Cambridge University Press.
3. Geometric Partial Differential Equations, G. Sapiro, Cambridge University Press.
4. Mathematical Problems in Image Processing, G. Aubert and P. Kornprobst, Springer Verlag.
5. Numerical Solution of PDEs in Science and Engineering Lapidus and Pinder, McGraw Hill.

36. **CSL746 MODELING AND SIMULATION 4 CREDITS (3-0-2)**
Prerequisite: Knowledge of Probability theory

Introduction: Systems, models, deterministic and stochastic systems, static and dynamic systems, discrete event simulation, continuous simulation, Monte Carlo simulation. Discrete Event Simulation: Time-advance mechanisms, event modeling of discrete dynamic systems, event graphs, process oriented and event oriented approaches, single-server single queue model. GPSS: Program model, entities and transactions, blocks in GPSS, user defined functions, SNA, logic switches, save locations, user chains, tabulation of result, programming examples. Random Number Generation: Congruence generators, long period generators, statistical quality measures of generators, uniformity and independence testing, chi-square and other hypotheses testing, runs testing. Random Variate Generation: random variable, probability density and distribution functions, Location, scale and shape parameters, discrete and continuous probability distributions; Inverse transform method, composition and acceptance-rejection methods, efficiency and quality measures of generators; Input Modeling, selection of distribution for a random source, fitting distributions to data, constructing empirical distributions from data. Random Processes and Queuing Models: random process, discrete/continuous time processes, Markovian property, Markov chain, state transition diagrams, birth-death process, Little's theorem, steady state analysis of M/M/1 model; multi-server models, M/G/1 and other queuing models, Burke's theorem, network of queues, Jackson theorem.Network Simulation: SimEvent tool box in MATLAB, general features of network simulation packages, case study of OMNET++/ns2/ns3/NetSim.

Text Books:

1. Karian, Z.A. and Dudewicz, E.J., "Modern Statistical Systems and GPSS Simulation", 2nd Ed., CRC Press. 1999
2. Banks, J., Carson, L.S., Nelson, B.L. and Nicol, D.M., "Discrete Event System Simulation", 4th Ed., Pearson Education. 2007

Reference Books:

1. Law, A.M. and Kelton, W.D., "Simulation, Modeling and Analysis", 3rd Ed., Tata McGraw-Hill. 2003

2. Alberto Leon-Garcia, “Probability and Random Processes for Electrical Engineers”, 2nd Ed., Pearson Education 2011

37. **CSL747 MULTIMEDIA SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Image Procesing

An overview of multimedia systems and media streams; Source representation and compression techniques text, speech and audio, still image and video; Graphics and animation; Multi-modal communication; Multimedia communication, video conferencing, video-on-demand broadcasting issues, traffic shaping and networking support; Transcoding; Multimedia OS and middleware; Synchronization and QoS; Multimedia servers, databases and content management; Multimedia information system and applications.

Text Books:
1. Ralf Steinmetz and KlaraNahrstedt, Multimedia Systems, Springer.
2. J. D. Gibson, Multimedia Communications: Directions and Innovations, Springer.

Reference Books:
1. A. Puri and T. Chen, Multimedia Systems, Standards, and Networks, Marcel Dekker.
2. Iain E.G. Richardson, H.264 and MPEG-4 Video Compression, John Wiley.
3. BorivojeFurht, Handbook of Multimedia Computing, CRC Press.

38. **CSL748 Neural network and Soft Computing 4 CREDITS (3-0-2)**
Prerequisite:

Single layer neural network, linear reparability, general gradient descent, perceptron learning algorithm, multi-Layer perceptron: two-layers universal approximators, backpropagation learning, important parameters, Margin of a classifier, dual perceptron algorithm, learning nonlinear hypotheses with perceptron.
Introduction to Soft Computing, Components of Soft Computing, Importance of Soft Computing, Applications. Fuzzy Set Theory - Definition, Different types of fuzzy set membership functions. Fuzzy set theoretic operations, Fuzzy rules and fuzzy reasoning, Fuzzy inference systems. Rough set theory.Probabilistic Reasoning.Genetic Algorithms, Simulated Annealing, applications.Neural Networks- Artificial neural networks models, Supervised Learning, Unsupervised Learning, Applications.Hybrid Systems and applications.

Text Books:
1. E. Alpaydin, Introduction to Machine Learning, Prentice Hall of India, 2006.
2. Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence - Jang, Sun and Mizutani, Printice Hall.

Reference Book:
1. Soft Computing: Integrating Evolutionary, Neural, and Fuzzy Systems, by Tettamanzi, Andrea, Tomassini, and Marco. (2001), Springer.

39. **CSL749 OBJECT ORIENTED SYSTEMS AND DESIGN 4 CREDITS (3-0-2)**
Prerequisite: Programming / Object Oriented Programming

Review of programming practices and code-reuse; Object model and object oriented concepts; Object-oriented programming languages and implementation; Object-oriented analyses and design using UML structural, behavioral and architectural modeling; Unified development process, Software reuse design patterns, components and framework; Distributed object computing,

interoperability and middleware standards COM/DCOM and CORBA; Object-oriented database system data model, object definition and query language, object relational system.
Fundamental concepts of object oriented programming: Introduction to the principles of object-oriented programming (classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers).

Text Books:

1. Grady Booch, Object Oriented Analysis and Design, Addison-Wesley.
2. Grady Booch, James Rumbaugh and Ivar Jacobson, Unified Modeling Language Guide, Addison-Wesley.

Reference Books:

1. Bertrand Meyer, Object Oriented Software Construction, Prentice-Hall
2. Erich Gamma et al., Design Patterns: Elements of Reusable OO Software, Addison-Wesley.
3. Kim Bruce, Foundations of Object Oriented Languages, Prentice-Hall.
4. Benjamin C. Pierce, Types and Programming Languages, Prentice-Hall.
5. BjarneStroustrup, The Design and Evolution of C++, Addison-Wesley.
6. Saba Zamir, Handbook of Object Technology, CRC Press.

40. **CSL750 PARALLEL ALGORITHMS 4 CREDITS (3-0-2)**
Prerequisite: Design and Analysis of Algorithms

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.

Text Books:

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.

Reference Books:

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

41. **CSL751 PARALLEL AND DISTRIBUTED COMPUTING 4 CREDITS(3-0-2)**
Prerequisite: Design and Analysis of Algorithms, Computer Organization and Architecture

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.

Text Books:

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

Reference Books:

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, 1sted, 2004.
4. W. Buchanan, Distributed Systems and Networks, Tata McGraw Hill, 2004.
5. P. S. Pacheco, Parallel Programming with MPI, Morgan Kaufmann, 1997.

42. **CSL752 PATTERN RECOGNITION 4 CREDITS (3-0-2)**
Prerequisite:

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.

Text Books:

1. RajjanShighal, 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.

Reference Books:

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

43. **CSL753 PRINCIPLES OF MANAGEMENT 4 CREDITS (3-0-2)**
Prerequisite:

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.

Text Books:

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.

Reference Books:

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.

44. **CSL754 QUANTUM COMPUTING 4 CREDITS (3-0-2)**
Prerequisite: None

Mathematical foundations; quantum mechanical principles; quantum entanglement; reversible computation, qubits, quantum gates and registers; universal gates for quantum computing; quantum parallelism and simple quantum algorithms; quantum Fourier transforms and its applications, quantum search algorithms; elements of quantum automata and quantum complexity theory; introduction to quantum error correcting codes; entanglement assisted communication; elements of quantum information theory and quantum cryptography.

Text Books:

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press.
2. JozefGruska, Quantum Computing, McGrawHill.

Reference Books:

1. Lecture notes by John Preskill and N. D. Mermin available in the Internet.
2. Los Alamos Quant_ph archive.5.Current Literature.

45. **CSL755 REAL TIME SYSTEMS 4 CREDITS (3-0-2)**
Prerequisite: Operating Systems

Introduction to real time system, embedded systems and reactive systems; Hard and soft real time systems; handling real time; specification and modeling; design methods; real time operating systems; validation and verification; real time process and applications; distributed real time systems.

Text Books:

1. R. Mall, Real Time Systems: Theory and Practice, Pearson Education, 2007.
2. C.M.Krishna and K.G.Shin, Real Time Systems, Tata McGraw Hill, 1997.

Reference Books:

1. Jane Liu, Real Time Systems, Pearson Education, 2000.
2. Phillip A. Laplante, Seppo J. Ovaska, Real-Time Systems Design and Analysis: Tools for the Practitioner, Wiley Pub.
3. Williams, Real Time Systems Development, Elsevier
4. Albert M.K. Cheng, Real Time Systems: Scheduling, Analysis and Verification, Wiley India.

46. **CSL756 SELECTED TOPICS IN ALGORITHMS 4 CREDITS (3-0-2)**

Prerequisite: Algorithms

The objective of this course is to familiarize students with some contemporary research in the area of algorithm design and analysis. The treatment will be theoretical with emphasis on problem solving and will be primality assignments based.

Models of computation and efficiency: Searching faster than O(log n), sorting faster than O(n log n).

Randomized algorithms in graphs and geometry: The impact of using randomization for designing algorithms that are simpler and often more efficient than the deterministic counterparts for several fundamental problems like MST, mincuts, spanners, convex hulls, triangulations, etc. Typically analysis is often harder than design.

Approximation algorithms: A set of rapidly evolving techniques that lead to provable approximation guarantees for hard optimization problems within polynomial running times. Unlike other communities dealing with the same problems the emphasis here is on provability of general instances and goes hand-in-hand with the "hardness of approximation" theory.

Each of the topics on their own could be easily a full semester course, so depending on the class response; we may pick and choose from the above list of topics.

Text Books:

1. Rajeev Motwani and PrabhakarRaghavan, Randomized Algorithms, Cambridge University Press.
2. Kurt Mehlhorn, Data Structures and Algorithms I (Sorting and Searching), Springer.

Reference Books:

1. Vijay Vazirani, Approximation Algorithms, Springer.
2. Thomas H. Cormen, Algorithms Unlocked, MIT Press

47. **CSL757 SOFTWARE DESIGN 4 CREDITS (3-0-2)**

Prerequisite: Discrete Structures

Introduction, Review of the software development context in relation to design patterns, 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, Behavioral Patterns: Chain of Responsibility, Command, Interpreter, Behavioral Patterns: Iterator, Mediator, Memento, Behavioral Patterns: Observer, State, Strategy, Behavioral Patterns: Template Method, Visitor, Discussion of behavioral pattern, What to expect from design pattern, The pattern Community.

Text Books:

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.

Reference Books:

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 DeployingMessaging Solutions. Addison-Wesley. ISBN 0-321-20068-3.
3. Freeman, Eric T; Elisabeth Robson, Bert Bates, Kathy Sierra (2004). Head First Design Patterns. O'ReillyMedia. ISBN 0-596-00712-4.

48. **CSL758 Software Engineering 4 CREDITS (3-0-2)**
Prerequisite: Algorithms, Discrete Structure

Software Life Cycle Models, Managing software projects, Project management concepts, Software processand Project metrics, Software Project Planning, Risk Analysis and Management, Project scheduling andtracking, Software Quality Assurance, Software Configuration Management. Conventional methods for softwareengineering, System Engineering, Requirements Analysis and Specifications, Analysis Modeling, DesignConcepts and principles, Architectural design, User Interface Design, Component level Design, SoftwareTesting Techniques, Software testing Strategies, Software Reliability, Technical metrics for software, CASEtools, Software Maintenance, Software Reusability. Object Oriented software engineering: Object OrientedConcepts and principles, Object Oriented analysis, Object Oriented Design, and Object Oriented testing,Technical metrics for Object Oriented Systems, Specialtopics in Software Engineering.

Text Books:
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.

Reference Books:
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.

49. **CSL759 SOFTWARE PROJECT, PROCESS AND QUALITY MANAGEMENT**
4 CREDITS (3-0-2) Prerequisite: Software Engineering

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.

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

Reference Books:
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.

50. **CSL760 SOFTWARE TESTING 4 CREDITS (3-0-2)**

Prerequisite: Software Engineering

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'scyclomatic 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.

Text Books:

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

Reference Books:

1. G. J. Myers, The art of software testing, Wiley Inter Science 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.

51. **CSL761 SOCIAL NETWORK ANALYSIS 4 CREDITS (3-0-2)**
Prerequisite: None

Social Network Analysis: Preliminaries and definitions, Erdos Number Project, Centrality measures, Balance and Homophily. Random graph models: Random graphs and alternative models, Models of network growth, Navigation in social Networks .Network topology and diffusion, Contagion in Networks, Complex contagion, Percolation and information, Epidemics and information cascades.Cohesive subgroups, Multidimensional Scaling, Structural equivalence, roles and positions, Ego networks, Weak ties, Structural holes.Small world experiments, small world models, origins of small world, Heavy tails, Small Diameter, Clustering of connectivity.The ErdosRenyi Model, Clustering Models, Preferential Attachment.Navigation in Networks Revisited, Important vertices and page rank algorithm, towards rational dynamics in networks, basics of game theory.Coloring and consensus, biased voting, network formation games, network structure and equilibrium, behavioral experiments, Spatial and agent-based models.

Text Books:

1. S. Wasserman and K. Faust. Social Network Analysis: Methods and Applications (Cambridge, Cambridge University Press, 1994).
2. D. Easley and J. Kleinberg, Networks, Crowds and Markets: Reasoning about a highly connected world

52. **CSL762 SPEECH AND NATURAL LANGUAGE PROCESSING 4 CREDITS (3-0-2)**
Prerequisite: Data Structures

Speech and Natural Language Processing: Introduction; Brief Review of Regular Expressions and Automata; Finite State Transducers; Word level Morphology and Computational Phonology; Basic Text to Speech; Various types of speech sounds and their characteristics, Speech hearing:

Mechanism for human hearing: Learning to recognize human sounds, acquired knowledge vs vocabulary - based methods. Analysis of speech: Frequency and time domain based methods: FFT, computation of pitch, spectrograms, LPC, spectrum, ZCR, etc. Representation of acoustic events. Components of a Speech recognition system: Input, feature analysis, modelling and decision rule, vocabulary. Data compression: Vector Quantization, codebook design, Lloyd's quantizer design, K-means algorithm, LBG algorithm for speech. Speech modelling: Stochastic processes: Markov processes, Hidden Markov modelling. Components of an HMM, training and building of HMMs: Viterbi algorithm, Baum-Welch algorithm, etc. Implementation of a speech recognition system: Time/space consideration, designing the interface, self-learning mechanism.Introduction to HMMs and Speech Recognition.Indian language case studies; Part of Speech Tagging; Parsing with CFGs; Probabilistic Parsing. Representation of Meaning; Semantic Analysis; Lexical Semantics; Word Sense; Disambiguation; Discourse understanding; Natural Language Generation; Techniques of Machine Translation; Indian Language case studies.

Text Books :

1. L. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall, 1993.
2. L. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.

Reference Books:

1. K. Sayood, Introduction to Data Compression, 2nd Ed, Morgan Kaufmann, 2000.
2. D. O'Shaughnessy, Speech Communications: Human and Machine, 2nd Ed, IEEE Press, 2000.
3. Gersho and R. M. Gray, Vector Quantization and Signal Compression, Kluwer Academic, 1991.

53. **CSL763 THEORY OF PROGRAMMING LANGUAGES 4 CREDITS (3-0-2)**
Prerequisite: Theory of Computation

Syntax of Programming Languages, Formal languages and automata theory: Finite automata, regular languages, pushdown automata, context free languages, linear bounded automata, context sensitive languages, Turing machines and recursively enumerable sets. Theory of LR(k) parsing, attribute grammars. Semantics of programming languages: Basic mathematical introduction: Propositional and predicate calculus, lambda calculus, algebraic structures. Sequential languages (imperative and applicative): operational semantics, Vienna definition methods. Denotational semantics: Scott-Strachy theory, axiomatic semantics: Floyd-Hoare approach, temporal logic, algebraic semantics and data types

Text Book:

1. John C. Mitchell, Foundations for Programming Languages, MIT Press.
2. Ravi Sethi, Programming Languages: Concepts and Constructs, Addison-Wesley.

Reference Books:

1. Glynn Winskel, A Formal Semantics of Programming Languages: An Introduction, MIT Press.
2. Daniel P. Friedman, Mitchell Wand and Christopher T. Haynes, Essentials of Programming Languages, Prentice Hall of India.
3. H. P. Barendregt, The Lambda Calculus: Its Syntax and Semantics, North-Holland.

54. **CSL764 UBIQUITOUS COMPUTING 4 CREDITS (3-0-2)**
Prerequisite: COMPUTER NETWORKS

Overview of wireless technologies, Signal propagation, Multiplexing, Modulation, and Spread spectrum techniques. Media access control: FDMA, TDMA, CDMA. Cellular systems: AMPS, GSM, DECT, UMTS, IMT-2000. CDMA-based cellular systems. Satellite systems: basic routing,

localization, and handoff issues. Wireless Networks: packet radio network, Wireless LAN: IEEE 802.11b, Blue-tooth, Wireless ATM. Wireless Application Protocol (WAP) and WML. Mobile Networking: Mobile IP, Ad-Hoc Networks: AODV, DSR, DSDV routing. Wireless TCP: indirect TCP, Snooping TCP, Mobile TCP, Information Management, Location-Independent and Location dependent computing models, Mobile applications and services, Security.

Text Books:

1. Stefan Poslad,Ubiquitous Computing: Smart Devices, Environments and Interactions
2. John Krumm, Ubiquitous Computing Fundamentals

55. **CSL765 VLSI SYSTEM DESIGN 4 CREDITS (3-0-2)**

Prerequisite: None

Introduction to VLSI Design, Different types of VLSI design styles: Full custom, standard cell based, gate array based, programmable logic, field programmable gate arrays etc. VLSI Design flow. CMOS logic: PMOS, NMOS and CMOS, Electrical characteristics, operation of MOS transistors as a switch and an amplifier, MOS inverter, stick diagram, design rules and layout, delay analysis, different type of MOS circuits: Dynamic logic, BiCMOS, pass transistors etc. CMOS process, Combinational logic cells, Sequential logic cells, Data path logic cells, I/O cells. ASIC Library Design: Transistors as Resistors and parasitic Capacitance, Logical effort, gate array, standard cell and data path cell design. Introduction to hardware description language (HDL) Verilog/VHDL.A logic synthesis example. Floor-planning and Placement: I/O and power planning, clock planning. Routing global and detailed. Example design technique: mapping of architecture to silicon.

Text Books:

1. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, Springer, 1st edition, 1992.
2. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall, 2nd edition, 2003

References Books:

1. G. De Micheli. Synthesis and optimization of digital circuits, 1st edition, 1994.
2. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004.
3. Bushnell and Agrawal, Essentials of Electronic Testing for Digital, Memory & Mixed-Signal Circuits, Kluwer Academic Publishers, 2000.

56. **CSL766 WIRELESS NETWORK SECURITY 4 CREDITS (3-0-2)**

Prerequisite: Computer Networks

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.

Text Books:

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

57. **CSL767 WIRELESS SENSOR NETWORKS 4 CREDITS (3-0-2)**

Prerequisite: Computer Networks

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, Tiny DB query processing, Query processing scheduling and optimization, Data Centric Storage. Special topics in wireless sensor networks.

Text Books:

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.

Reference Books:

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

58. **CSL768 INTERNET OF THINGS** **4 CREDITS (3-0-2)**

Prerequisite: None

Introduction: Definition, phases, Foundations, Policy, Challenges and Issues-identification-security, privacy. Components in internet of things: Control Units, Sensors, Communication modules, Power Sources, Communication Technologies, RFID, Bluetooth, Zigbee, Wifi, Rflinks, Mobile Internet, Wired Communication. **Programming the Microcontroller for IOT**: Basics of Sensors and actuators, examples and working principles of sensors and actuators, Cloud computing and IOT, Arduino/Equivalent Microcontroller platform, Setting up the board-Programming for IOT, Reading from Sensors, Communication: Connecting microcontroller with mobile devices–communication through Bluetooth and USB, connection with the internet using wifi / Ethernet. **Resource Management in the internet of things**: Clustering, Software Agents, Data Synchronization, Clustering Principles in an Internet of Things Architecture, The Role of Context, Design Guidelines, Software Agents for Object, Data Synchronization, Types of Network Architectures, Fundamental Concepts of Agility and Autonomy, Enabling Autonomy and Agility by the Internet of Things, Technical Requirements for Satisfying the New Demands in Production-The Evolution from the RFID-based EPC Network to an Agent based Internet of Things, Agents for the Behaviour of Objects. **Business models for the internet of things**: The Meaning of DiY in the Network Society, Sensor-actuator Technologies and Middleware as a Basis for a DiY Service Creation Framework, Device Integration, Middleware Technologies Needed for a DiY Internet of Things Semantic Interoperability as a Requirement for DiY Creation-Ontology, Value Creation in the Internet of Things, Application of Ontology Engineering in the Internet of Things-Semantic Web, Ontology, The Internet of Things in Context of EURIDICE, Business Impact. **From the Internet of Things to Web of Things**: Resource, oriented Architecture and Best Practices, Designing RESTful Smart Things, Web-enabling Constrained Devices, The Future Web of Things, Set up cloud environment, send data from microcontroller to cloud, Case studies, Open Source e-Health sensor platform, Be Close Elderly monitoring, Other recent projects.

Text Books:
1. Charalampos Doukas, Building Internet of Things with the Arduino, Create space, April 2002.
2. Dieter Uckelmann et.al, "Architecting the Internet of Things", Springer, 2011

Reference books:
1. Luigi Atzor et.al, "The Internet of Things: A survey, ", Journal on Networks, ElsevierPublications, October, 2010
2. http://www.postscapes.com/
3. http://www.theinternetofthings.eu/what-is-the-internet-of-things

59. **CSL769 SERVICE ORIENTED ARCHITECTURE PROTOCOL 4 CREDITS (3-0-2)**

Prerequisite: None

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, WS-Security.

Text Books:
Thomas Erl, Service-Oriented Architecture: Concepts, Technology, and Design, Pearson Education, 2005

1. Dan Woods and Thomas Mattern, Enterprise SOA Designing IT for Business Innovation, First Editioned.: O'REILLY, 2006.

Reference Books:

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.