M. Tech. Computer Science and Engineering

Two-Year Programme

Academic Curriculum (2018 – 19 onwards)

First Year

	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration	Weightage (%)		
			L	T	P		Hours	CW*	MTE**	ETE
Autumn Semester	CS 521	Big Data Analytics	3	1	0	4	3	10	40	50
	CS 511	Adhoc Sensor Networks	3	1	0	4	3	10	40	50
	CS 515	Machine Learning	3	1	0	4	3	10	40	50
	CS 523	Operations Research	3	0	0	3	3	10	40	50
		Elective I	4	0	0	4	3	10	40	50
	CS517	Adhoc Sensor Networks Lab	0	0	2	1	2	20	40	40
	RM 17.101	**Research Methodology**	**2**	**0**	**0**	**2**	**2**	**10**	**40**	**50**
	CS 525	Machine Learning Lab	0	0	2	1	2	20	40	40
	CS 527	Operations Research Lab	0	0	2	1	2	20	40	40

	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration	Weightage (%)		
			L	T	P		Hours	CW*	MTE**	ETE
Spring Semester	CS506	Distributed Operating Systems	3	0	0	3	3	10	40	50
	CS508	Soft computing Paradigms	3	1	0	4	3	10	40	50
	CS510	Digital Image Processing & Analysis	3	1	0	4	3	10	40	50
	CS512	Advances in Database Management Systems	3	1	0	4	3	10	40	50
		Elective II	4	0	0	4	3	10	40	50
	CS514	Distributed Operating Systems lab	0	0	2	1	2	20	40	40
	CS516	Digital Image Processing & Analysis lab	0	0	2	1	2	20	40	40
	CS518	ADBMS lab	0	0	2	1	2	20	40	40
	HS501	Technical Communication***(optional)	2	0	0	2	3	10	40	50
	Sub Total		18	3	6	24/**24**				

*** If a student opts for this optional course the corresponding credits will be added to her account.

List of Electives

Elective I

1. CS 563 Advances in Distributed Computing
2. CS 565 Advanced Compiler Construction
3. CS 567 BioInformatics
4. CS 569 Advanced Computer Graphics
5. CS 571 Advances in Algorithm Design

Elective II

1. CS 562 Mobile Cloud Computing
2. CS 564 Machine Intelligence & Robotics
3. CS 566 Natural Language Processing
4. CS 568 Advanced Software Engineering
5. CS 570 Mathematical Modelling

M. Tech. Computer Science & Engineering

Two-Year Programme

Academic Curriculum (2017 – 18 onwards)

Second Year

	Course Code	Course Title	Contact Hours per			Credits	ETE Duration	Weightage (%)		
			L	T	P		Hours	CW*	MTE**	ETE
Autumn Semester	CS 601	Seminar	0	0	--	4	-	100		
	CS 603	Project	0	0	--	4	-	100		
	CS 608	Dissertation Preliminary	0	0	--	16	-	-	-	-
	Sub total		**2**	**0**	**--**	**24**				

	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration	Weightage (%)		
			L	T	P		Hours	CW*	MTE**	ETE
Spring Semester	CS 606	Dissertation Final	0	0	--	20	-	100		
	Sub Total		**0**	**0**	**--**	**20**				

Total Credits = 92

* **Theory:** Assignments and regularity will be evaluated out of 10(ten) marks in a semester.

****Theory :** Two mid-term examinations of 20 (twenty) marks each.

******* The student may decide to take HS 501 in the even semester as an optional paper by consulting the course coordinator. If a student opts to take this paper, the appropriate credit shall be added to her account.

CS 521 **Big Data Analytics** **Total Lectures: 40**

Credit:3-1-0-4

Objective(s):

- To learn Big Data characteristics
- To learn Hadoop architecture and functioning of Map-Reduce.
- To learn other Big data tools like HIVE, HIVEQL and HBASE.

1. **INTRODUCTION: D**istributed file system – Big Data and its importance, four Vs, drivers for Big data, Big data analytics, Big data applications, algorithms using map reduce, matrix-vector multiplication by Map Reduce. [8]

2. **Introduction to HADOOP:** Apache HADOOP & HADOOP ecosystem , moving data in and out of Hadoop , understanding inputs and outputs of MapReduce , data serialization [8]

3. **HADOOP Architecture:** HADOOP architecture, HADOOP storage: HDFS, common HADOOP shell commands , anatomy of file write and read., namenode, secondary namenode, and datanode, HADOOP MapReduce paradigm, map and reduce tasks, job, task trackers ,cluster setup, SSH & HADOOP configuration, HDFS administering, monitoring & maintenance. [8]

4. **HADOOP Ecosystem and YARN**: HADOOP ecosystem components, schedulers, fair and capacity, HADOOP 2.0 new features, namenode, high availability, HDFS federation, mrv2, YARN, running mrv1 in YARN. [8]

5. **HIVE and HIVEQL, HBASE**: HIVE architecture and installation, comparison with traditional database, hiveql, querying data, sorting and aggregating, map reduce scripts, joins & subqueries, Hbase concepts, advanced usage, schema design, advance indexing - Pig, Zookeeper - how it helps in monitoring a cluster, Hbase uses Zookeeper and how to build applications with Zookeeper. [8]

Outcome(s): The students will be able to carry out research in Big Data using the latest tools.

Text Books:

1. Chris Eaton, Dirk deroos et al. , Understanding Big data , McGraw Hill, 2012.
2. Tom White, HADOOP: The definitive Guide , O Reilly 2012.

Reference Books:

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, Professional Hadoop Solutions, Wiley, ISBN: 9788126551071, 2015.
2. Jy Liebowitz, Big Data and Business analytics, CRC press, 2013.

CS 515 **Machine Learning** **Total Lectures: 40**

Credit:3-1-0-4

Objective(s):

- To learn the Machine learning concepts.
- To learn different models of Machine learning.

1. **Foundations of Learning:** Components of learning, learning models, geometric models, probabilistic models, logic models, grouping and grading, learning versus design, supervised learning, unsupervised learning, reinforcement learning , theory of learning, feasibility of learning, error and noise, training versus testing, theory of generalization, generalization bound, approximation generalization trade off, bias and variance, learning curve. [12]

2. **Linear Models:** Linear classification, univariate linear regression, multivariate linear regression, regularized regression, logistic regression, perceptron, multilayer neural networks, learning neural networks structures, support vector machines, soft margin SVM, going beyond linearity, generalization and overfitting, regularization, validation. [10]

3. **Distance-based Models:** Nearest neighbor models, K-means clustering, hierarchical clustering, k-d trees, locality sensitive hashing, non-parametric regression, ensemble learning, bagging and random forests, boosting, meta learning. [8]

4. **Tree and Rule Models:** Decision trees, learning decision trees, ranking and probability estimation trees, regression trees, clustering trees, learning ordered rule lists, learning unordered rule lists, descriptive rule learning, association rule mining, first-order rule learning. [10]

5. **Reinforcement Learning:** Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal-difference learning, active reinforcement learning, exploration, learning an action utility function, generalization in reinforcement learning, policy search, applications in game playing, applications in robot control. . [10]

Outcome(s): Students will be able to

- Compare and apply Machine learning models for different problems.
- Carry out research in the area of Machine learning.

Text Books:

1. T. M. Mitchell, Machine Learning, McGraw Hill, 1997.
2. M. Mohri, A. Rostamizadeh, and A. Talwalkar, Foundations of Machine Learning, MIT Press, 2012.

Reference Books:

1. P. Flach, Machine Learning: The art and science of algorithms that make sense of data, Cambridge University Press, 2012.

2. S. Russel and P. Norvig, Artificial Intelligence: A Modern Approach, Third Edition, Prentice Hall, 2009.

CS 523 **Operations Research** **Total Lectures: 40**
Credit: 3-1-0-4

Objective(s): To learn major Operations research techniques.

1. **Introduction to Operation Research:** Origins of or, nature, impact and phases of OR, solving the OR model , operation research as tool for decision support system, productivity improvement, overview of OR research techniques. [6]

2. **Deterministic OR Models:** Formulation of linear programming problem, linear programming models, assumptions of linear programming, graphical method of solving LP problem, Simplex method for solving LP problem, special cases in Simplex method application. [6]

3. **Linear Programming Extensions:** Introduction and formulation of transportation problem, types of transpiration problems, methods of initial feasible solution, methods of optimum solution, unbalanced transportation problem, introduction to assignment problem, solution of an assignment problem, the transshipment model. [8]

4. **Decision, Game & Queueing Theory:** Formulation of two person, zero-sum games, solving simple games, mixed strategies, non-zero sum games, basic structure & components of decision, decision criteria, decision trees, basic characteristics of queueing system, terminologies & notation, Poisson process of queueing, M/M/1 system queueing model. queuing decision models. [8]

5. **Hybrid OR Models, Project Management PERT & CPM:** Assumption and comparison PERT & CPM, algorithms of PERT CPM techniques, fundamentals of network model, guidelines for network construction, critical path analysis, methods based on time estimates to find critical paths, concept of slack & oats in network analysis, Project Evaluation & Review Techniques (PERT) [6]

6. **Dynamic Programming:** Terminologies, multi decision process, Bellman's principles of optimality, characteristics of dynamic programming problems, dynamic programming algorithms, solving LPP using dynamic programming, recent applications of dynamic programming in OR. [6]

Outcome(s): Students will be able to apply Operation Research techniques relevant to their area of research.

Text Books:
1. Hamdy A Taha, Operations Research: An Introduction, Pearson education India, 8th Edition, 2011.
2. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research, 8th edition McGraw-Hill, 2001.

Reference Books:
1. Richard Bronson , Govindasami Naadimuthu, Schaum's Outline of Operations Research, 2nd edition, McGraw-Hill Education, 1997.
2. Wayne L. Winston, Operations Research: Applications and Algorithms, Cengage Learning, 2003.

Total Lectures: 40

RM 17.101 **Research Methodology** **Credit: 2-0-0-2**

Prerequisite(s):

Objective(s):

1. **Introduction:** Meaning of research, Objectives, Motivation for Research, Types of Research, Research Approaches, Research Process,Validity and Reliability in Research. [2]

2. **Problem Formulation:** Identification, Selection and Formulation ofa Research Problem, Criteria of a good Research Problem, Reviewof Literature, Research Gaps. [4]

3. **Research Design:** Research Framework, Meaning &Significance of Research Designs, Features of a good Research Design, Types of Research Design [4]

4. **Data for research:** Types of Data, Sources of Data, Methods of Collecting Data, Data Presentation Techniques. Methods of DataAnalysis. [4]

5. **Data Analysis and Simulation Tool:** Introduction to SPSS, MATLAB, Network Simulators, ETAP, Solid Works, MultiSim. [8]

6. **Report Writing:** Types of Reports, Contents, Style Manuals, Results & Findings, Contributions, Implications, Scope for future work and conclusion, Referencing Styles, Anti Plagiarism Policy. [4]

Text Books:

1. R.Pannershelvam, "ResearchMethodology" PrenticeHall India, New Delhi, 2nd Edition, 2013.

Reference Books:

1. C.R.Kothari,"ResearchMethodology: MethodsandTechniques",New Age International (p)Limited,Publishers New Delhi, 4nd edition,2018.

CS 525 **Machine Learning Lab** **Credit: 0-0-2-1**

Objective(s): To learn the implementation of different Machine learning models.

Contents: Experiments based upon basic learning models, classification, generalization.

Experiments based upon linear models of learning.

Experiments based upon distance models.

Experiments based upon tree and rule models.

Experiments based upon reinforcement learning.

Outcome(s): Students will be able to apply and compare different Machine learning models.

CS 527 **Operations Research Lab** **Credit: 0-0-2-1**

Objective(s): To implement the Operations Research techniques.

Contents: Experiments based upon linear programming.

Experiments on Simplex method.

Experiments based upon Assignment problem and Transportation model.

Experiments based upon Game theory and Queuing theory.

Experiments based upon CPM/PERT.

Experiments based upon dynamic programming.

Outcome(s): Students will be able to implement and analyze different OR techniques.

CS 509 High Performance Computer Architecture 3-1-0-4

1. Overview: Necessity of high performance, Constraints of conventional architecture, Parallelism in uniprocessor system, Evolution of parallel processors, future trends, Architectural Classification, Applications of parallel processing, Instruction level Parallelism and Thread Level Parallelism, Explicitly Parallel Instruction Computing (EPIC) Architecture, Performance Metrics and Measures, Speedup Performance Laws. [6]

2. Pipeline Architecture: Principles and implementation of Pipelining, Classification of pipelining processors, General pipelining reservation table, Design aspect of Arithmetic and Instruction pipelining, Pipelining hazards and resolving techniques, Data buffering techniques, Job sequencing and Collision, Advanced pipelining techniques, loop unrolling techniques, out of order execution, software scheduling, trace scheduling, Predicated execution, Speculative loading, Register Stack Engine, Software pipelining. [8]

3. Vector and Array Processor: Basic vector architecture, Issues in Vector Processing, Vector performance modeling, vectorizers and optimizers, SIMD Computer Organization Masking and Data network mechanism, Inter PE Communication, Interconnection networks of SIMD, Static Vs Dynamic network, cube, hyper cube and Mesh Interconnection network. Parallel Algorithms for Array Processors. [8]

4. Multiprocessor Architecture: Loosely and Tightly coupled multiprocessors, Processor characteristics of multiprocessors, Inter Processor communication network, Time shared bus, Crossbar switch, Multiport Memory Model, Memory contention and arbitration techniques, Cache coherency and bus snooping, Massively Parallel Processors (MPP), Processor, Inter Processor Communication and Synchronization. [8]

5. Multithreaded Architecture: Multithreaded processors, Latency hiding techniques, Principles of multithreading, Issues and solutions. [4]

6. Parallel Programming Techniques: Message passing program development, Synchronous and asynchronous message passing, Message passing parallel programming, Shared Memory Programming, Data Parallel Programming. [6]

Text Books:

1. Kai Hwang, Faye A. Briggs, "Computer Architecture and Parallel Processing", McGraw Hill International Edition, 2004.
2. Kai Hwang, "Advanced Computer Architecture", Tata McGraw Hill Edition, 2001.

Reference Book:

1. William Stallings, "Computer Organization and Architecture, Designing for performance" Prentice Hall, Sixth Edition, 2003.

CS 511 Ad hoc Sensor networks 3-1-0-4

1. Ad hoc Networks: Introduction and Definitions, Ad hoc Network Applications, Design Challenges. [3]

2. Routing in Mobile Ad hoc Networks: Introduction, Flooding, Proactive Routing, On Demand Routing, Proactive Versus on demand Debate, Location based Routing. [4]

3. Multicasting in Ad hoc Networks: Introduction, Classifications of Protocols, Multicasting Protocols, Broadcasting. Protocol Comparisons, Overarching Issues. [4]

4. Transport layer Protocols in Ad hoc Networks: Introduction, TCP and Ad hoc Networks,Transport Layer for Ad hoc Networks: Overview, Modified TCP, TCP-aware Cross-layered Solutions. Ad hoc Transport Protocol. [5]

5. QoS Issue in Ad hoc Networks: Introduction, Definition of QoS, Medium Access Layer, QoS Routing, Inter- Layer Design Approaches. [4]

6. Security in Mobile Ad hoc Networks: Vulnerabilities of Mobile Ad hoc Networks, Potential Attacks, Attack Prevention Techniques. Intrusion Detection Techniques. [4]

7. Overview of Wireless Sensor Networks (WSNs): Introduction, Constraints and Challenges, Advantages of Sensor Networks, Sensor Network Applications. [2]

8. Routing Protocols: Geographic, Energy-Aware Routing – Unicast Geographic Routing, Routing on a Curve, Energy-Minimizing Broadcast, Energy-Aware Routing to a Region; Attribute-Based Routing – Directed Diffusion, Rumor Routing. [8]

9. Security in WSNs: Introduction: IEEE 802.11b Security Mechanisms, WEP Security Issues, WEP Improvements, Wireless Security Threats and Risks: Types of Security Threats, Physical Security of Wireless Devices, WLAN Attacks. Risk Mitigation and Countermeasures: Basic Countermeasures, AAA Infrastructure Solutions, Additional Enhancements. [6]

Text Books:

1. Prasant Mohapatra and Srihanamurthy, "Ad Hoc Networks Technologies and Protocols", Springer, Springer International Edition, 2009.
2. Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks", John Wiley & Sons, Inc., Pub!ication, 2007.
3. Zhao, Guibas, "Wireless Sensor Networks" , Elsevier, 2004.

Reference Book:

1. A.Boukereche, "Handbook of Algorithms for Wireless Networking and Mobile Computing", Chapman and Hall/CRC Computer and Information Science Series, 2007.

CS 513 Cryptography and Information Security 3-1-0-4

1. Introduction: Elements of Information Security, Category of computer securities, types of attacks and services. [4]

2. Cryptographic Techniques: plain text and Cipher text, Encryption and Decryption, Stenography, Symmetric and Asymmetric key Cryptography, Blowfish, Data encryption standard, (DES), Advanced Encryption Standard(AES) [6]

3. Number Theory: Introduction to ring and field, prime and relative prime numbers, modular arithmetic, Fermat's and Euler's theorem, primality testing, Euclid's Algorithm, Chinese Remainder theorem, discrete logarithms. [4]

4. **Public key Cryptography:** Public Key Cryptography and RSA, Key Management, Diffie-Hellman key Exchange, Elliptic Curve Architecture and Cryptography. [5]

5. Message Authentication and Hash Function: Authentication requirements, authentication functions, MAC, hash functions, MD5, SHA, Digital Signatures: Digital Signatures, authentication protocols, Digital certificates, Kerberos, Certificate authority. [9]

6. Information attacks: Recognizing Security Threats and countermeasure for Phishing, Virus, Trojan Horse, Worms, Spyware, Adware, Key logger, Denial of Service, Spamming, Port Scanning and Password cracking [4]

7. Web and IP Security: Secure Socket Layer(SSL), Secured Hyper Text Transfer Protocol(SHTTP),S/MIME, IP security overview, Authentication Header(AH), Encapsulating Security Payload(ESP), IP key management . [6]

8. **Case study**: IP spoofing attack, Cyber Laws. [2]

Text Books:

1. William Stallings, "Cryptography and Network Security – Principles and Practices", Prentice-Hall of India, 4/E edition, 2003.

Reference Books:

1.VK Pachghare, "Cryptography & Information Security", PHI, 2009

2. Atul Kahate, "Cryptography and Network Security", Tata McGraw-Hill, 2003.

MA 531 Advanced Computational Mathematics 3-0-0-3

1. Calculus of Finite Differences and Interpolation: Finite differences and difference operators, Construction of difference tables, Interpolation and extrapolation with equal intervals (Newton- Gregory forward, backward, Stirling and Bessel's formulas), Interpolation and extrapolation with unequal intervals (Newton's divided difference and Lagrange's formulas). [10]

2.Numerical Differentiation and Integration: Numerical differentiation with equal and unequal intervals, numerical integration (newton-Cotes quadrature formula, Trapezoidal, Simpson's 1/3, Simpson's 3/8, Weddle's and Romberg rules), Double and triple integration using Trapezoidal and Simpson's rules. [8]

3. Numerical Solution of Simultaneous Equations: Gauss elimination method (Partial Pivoting), Jacobie's iteration method, Gauss Jordan method, Gauss Siedel iteration method. [4]

4. Numerical Solution of Algebraic and Transcendental Equations: Bisection method, Regula falsi method (method of false position), Newton's Raphson method and its applications, Graeffe's root squaring method with error analysis. [6]

5. Numerical Solution of Ordinary and Partial Differential Equations: Numerical solution of ordinary differential equations of first order and first degree using Picard's, Taylor series, Euler, Euler's modified, Runge-Kutta method of fourth order and Milne's Predictor -Corrector method.

Classification of partial differential equations (elliptic, parabolic, and hyperbolic) Finite difference approximations to partial derivatives, Jacobi and Gauss Siedel method, Crank - Nicolson method, Solution of Laplace and Poisons equations. [14]

6. Linear Algebra: Review of group, ring and field , Vector Spaces, Subspaces, Linearly dependent and independent, Basis, Dimensions, Isomorphism, Linear transformations and their matrix representations ,Rank, Inverse of Matrices, Cauchy- Schwarz inequality , Eigenvalue, Eigenvectors. [10]

Text Books:

1. M.K.Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, 2012.

2. B.S.Grewal, Numerical Methods, BPB publication, 2012.

3. Introduction to Linear Algebra with applications by Jim Defranza and Daniel Gagliardi, TMH, Year 2013.

Reference Books:

1. Numerical Mathematics Analysis by James B. Scarborough.

2. Introduction Methods of Numerical Analysis by S.S. Shastry.

3. Applied Numerical methods with MATLAB by Steven C Chapra, TMH.

4. Introduction of Numerical Analysis by Forberg.

5. V. Rajaraman Computer oriented numerical methods 3rd edition PHI – 2012

6. Linear Algebra and Its applications by David C. Lay, Addison- Wisley(An imprint of Pearson education).

CS 517 Ad-hoc Sensor Networks Laboratory 0-0-2-1

1. Basics of Network Simulation
2. Simulating a Local Area Network
3. Measuring Network Performance
4. Simulation of a Satellite Network
5. Simulating a Wi-Fi Network
6. Simulating a Wi-MAX Network
7. Simulating a Mobile Ad-hoc Network
8. Simulating a Wireless Sensor Network
9. Setting up a Bluetooth Network
10. Setting up a Zig-Bee Network

CS 519 Cryptography & Information Security Lab 0-0-2-1

1. Implementation of Ciphers

a) Play fair

b) Hill cipher

2. Implementation of the concepts from number theory

a) Fermat's & Euler's Theorem

b) Primality testing

c) Chinese Remainder Theorem

3. Implementation of Symmetric key algorithms like AES/ DES

4. Implementation of Asymmetric key Algorithms like RSA/ DSA.

5. Implementing hash code using MD5/SHA. And generate digital signature

6. Generation of Virus.

MA 533 Advanced Computational Mathematics Laboratory 0-0-2-1

Implement the following in C/C++/MATLAB:

(1) Newton-Gregory's formulae for forward and backward interpolation.
(2) Stirling formula.
(3) Bessel's formula.
(4) Newton's divided difference formula.
(5)Lagrange's formula.
(6) Numerical differentiation.
(7) Numerical integration: Newton –Cotes quadrature formula..
(8) Trapezoidal rule.
(9) Simpson rules.
(10) Romberg rules.
(11) Solution of differential equations by Euler's method modified Euler's method.
(12) Runge-Kutta method.
(13) Milne's Predictor-Corrector method.
(14) Bisection method
(15) Regula Falsi method
(16) Newton – Raphson method.
(17) Graeffe's root squaring method.
(18) Gauss elimination method (with partial pivoting).
(19) Eigen values and eigen vectors.
(20) Solution of partial differential equations.

CS 506 Distributed Operating Systems 3-0-0-3

1. Introduction: Definition, Evolution of distributed computing system, Distributed computing system models- Minicomputer model, workstation model, workstation –server model, processor –pool model, hybrid model. Advantages of distributed operating system. [3]

2. Distributed computing environment: Design issues of distributed operating system- Transparency, Reliability, flexibility, Performance, scalability, heterogeneity, security. Distributed computing environment- Definition, components, and DCE cells. [5]

3. Message Passing: Introduction, issues in IPC by message passing, Synchronization, buffering –null buffer, single message buffer, unbounded capacity buffer, finite bound buffer. Multi datagram message, encoding and decoding of message data. Process addressing, failure handling , group communication.[6]

4. Remote Procedure call and Remote Method Invocation: RPC model, Transparency of RPC, Implementing RPC mechanism, Stub generation, RPC Messages, Marshaling Arguments and Results, Server Management, Parameter passing, semantics, call semantics. Communication protocols for RPC- request protocol, request/reply protocol, request/reply/acknowledge protocol, RPC heterogeneous environment, Light weight RPC. [8]

5. Remote Method Invocation(RMI) : Introduction, communication between distributed objects, design issues for RMI implementation of RMI , distributed garbage collection , time and global clock, clock synchronization, logical clock- Lamport time stamps, Vector time stamp, global state, event ordering , mutual exclusion, deadlock, election algorithms- Bully algorithm, Ring algorithm , distributed transactions. [5]

6. Distributed shared memory : Introduction, message passing vs DSM, implementation approaches to DSM, design and implementation issues- Structure and synchronization model. Granularity, Structure of shared memory space, consistency model, replacement strategy, thrashing. [6]

7. Processes and Processors in Distributed Systems: Threads, system models, processor allocation, scheduling fault tolerance. [4]

8. Distributed File System: Design, implementation, trends in distributed file system. [3]

Text Books:

1. Pradeep K. Sinha, "Distributed Operating Systems: Concepts and Design", Prentice-Hall of India, 3rd Printing, October 2001 .
2. Andrew S. Tanenbaum and Maarten van Steen, " Distributed Systems", PHI, second Printing, July 2003.

Reference Book:

1. G. Coulorius, J. Dollimore and T. Kinderberg, “Distributed Systems: Concepts and Design”, fourth edition, Addison Wesley, May 2005.

CS 508 Soft Computing Paradigms 3-1-0-4

1. **Artificial Neural Networks:** Definition, benefits of Artificial Neural Networks, terminology, neuron models, activation function, network architectures, learning process, types of learning: Hebbian, competitive, error-correction, Boltzmann learning. [8]

2. **Types of Neural Networks:** Feed forward neural network: Single layer perceptron, limitations, multi layer perceptron, back propagation algorithm, practical considerations, radial basis function network. Recurrent networks: Hopfield network, NARX model, state space model, recurrent multi layer perceptron, second order networks. Self-organizing map, and principal component analysis. [12]

3. **Fuzzy Logic:** Basic concepts of fuzzy logic, crisp sets and fuzzy sets, operations and properties of crisp sets and fuzzy sets, crisp and fuzzy relations, fuzzy rules, fuzzification and defuzzification. [7]

4. **Fuzzy Logic Applications:** Pattern recognition, control engineering, image processing, neuro fuzzy application. [3]

5. **Genetic Algorithms:** Basic concepts, working principles, genetic operators, genetic programming, parsing trees and mathematical foundation of genetic algorithm. Other optimization methods: Swarm Intelligence, ant colony optimization. [6]

6. **Hybrid Systems:** Neuro genetic systems, fuzzy genetic systems and neuro fuzzy genetic systems, applications. [4]

Text Books:

1. Li Min Fu, "Neural Networks in Computer Intelligence", Tata McGraw Hill Edition, 2008.
2. Simon S. Haykin , "Neural Networks- A Comprehensive Foundation", Prentice Hall, 2009.
3. S. Rajsekaran, G. A. Vijayalaxmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Application", Prentice Hall, 2010.

Reference Books:

1. B. Yegnanarayana, "Artificial Neural Networks", Prentice Hall, 2006.
2. S.N. Sivanandam, S. N. Deepa, "Principles of Soft Computing", Wiley India, 2008.
3. D.E. GoldBerg, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2009.

CS 510 Digital Image Processing and Analysis 3-1-0-4

1. Image Representation: Sampling, Quantization, Image Basis Function, Image Types, Fourier Transform, Discrete Cosine Transform, Walsh- Hadamard Transform, Wavelet Transform, Principal Component Analysis. [6]

2. Image Enhancement and Restoration: Contrast Stretching, Histogram Specification, Histogram Equalization, Enhancement Using Arithmetic/Logic Operations, Smoothing Sharpening, Low-Pass Filters, High-Pass Filters, Bandpass Filters, Homomorphic Filtering, Restoration Process Model, Noise Models, Inverse Filtering , Minimum Mean-Square Error Restoration. [8]

3. Image Morphology: Introduction, Logic Operations Involving Binary Images, Dilation and Erosion, Opening And Closing, Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening. [5]

4. Image Segmentation: Region Extraction, Pixel-Based Approach, Thresholding, Edge And Line Detection, Pattern Fitting Approach, Hough Transform, Radon Transform, Edge Linking And Edge Following, Edge, Corner Detection. [6]

5. Image Compression: Information Content of an Image, Lossless and Lossy Compression Algorithms, Compression Standards. [4]

6. Feature Extraction: Representation, Topological Attributes, Geometric Attributes, spatial Moments, Texture, Boundary Based Description, Region Based Description, Intensity Based and Relational Description. [6]

7. Recognition: Deterministic Methods, Clustering, Neural Network, Template Matching, Statistical Classification, Syntactic Recognition, Tree Search, Graph Matching. [5]

Text Books:

1. Gonzaloz R. C. and Woods R.E., "Digital Image Processing", Prentice Hall 2002.
2. Jain A.K., "Fundamentals of Digital Image Processing", Prentice Hall 1989.

Reference Books:

1. William K. Pratt, "Digital Image Processing", John Wiley, 2001.
2. B. Chanda and D. Dutta Majumder ," Digital Image Processing and Analysis",PHI, 2002

CS 512 Advances in Database Management Systems 3-1-0-4

1. **Object and Object-Relational Databases:** Introduction, Object relational features, Object database extensions to SQL, ODMG object model and the object definition language (ODL) [8]

2. **Extensible Markup Language (XML)**: Structured, Semi structured and Unstructured data, XML hierarchical Data model. XML documents, DTD and XML Schema. Storing and extracting XML documents from databases, XML Languages. Extracting XML documents from relational databases. [8]

3. **Query Processing and Optimization:** Translating SQL queries into relational algebra. Algorithms for external sorting, select, join, project and set operations. Implementing aggregate operations and outer joins. Combining operations using pipelining, heuristic query optimization, selectivity and cost estimates in query optimization, semantic query optimization. [8]

4. **Database Recovery:** Recovery concepts, no-undo/redo recovery based on deferred update, recovery techniques based on immediate update, shadow paging, ARIES algorithm, recovery in multidatabase systems, database backup and recovery from catastrophic failures. [5]

5. **Database Security:** Security issues, granting and revoking priviliges, role based access control for multilevel security, SQL injection, statistical database security, flow control, encryption and public key infrastructures, privacy issues and preservation, challenges of database security. [5]

6. **Distributed Databases:** Distributed Database concepts, types, distributed database architecture, fragmentation, distribution and allocation techniques, query processing and optimization in distributed databases, transaction management in distributed databases. [6]

Text Books:

1. Elmasri, Navathe, "Fundamentals of Database systems", Addison Wesley, sixth ed, 2010.
2. Raghu Ramakrishnan, Gehrke, "Database Management systems", McGraw Hill, third ed, 2009.

Reference Book:

1. Thomas m. Connolly, Carolyn E. Begg, "Database Systems", Pearson education, fifth ed, 2009.

CS 514 Distributed Operating Systems Laboratory 0-0-2-1

1. Study of UNIX commands with all their important options
2. Study system calls related to process & process control
3. Study system calls related to semaphore
4. Inter process communication using shared memory
5. Incrementing a counter in shared memory
6. Implement concurrent echo client-server application
7. Implement a distributed chat server using TCP sockets in java.
8. Simulation of Distributed mutual exclusion in java.
9. Write a program to implement RPC in “C”
10. Implement ‘Java RMI’ mechanism for accessing methods of remote systems.
11. Write a program to simulate the functionality of Lamport's Logical clock in C.
12. Write a program to Implement Vector clock in C.

CS 516 Digital Image Processing and Analysis Laboratory 0-0-2-1

1. Overview of MATLAB environment, Programming, Data types, Structure, Arithmetic / Logical operations, Cell arrays, Script files, Functions.
   Implement following image processing concepts using MATLAB.
2. Fourier transform, discrete cosine transform, Walsh- Hadamard transforms and principal component analysis.
3. Contrast Stretching, Histogram Equalization, and Enhancement using Arithmetic/Logic Operations.
4. Smoothing, Mean filter, Ordered Statistic Filter, Sharpening, Low-pass, High-pass filters, Bandpass and Homomorphic Filtering.
5. Image Restoration using Inverse filtering, Minimum Mean-square Error Restoration.
6. Logic Operations involving Binary Images, Dilation and Erosion, Opening and Closing, Boundary Extraction, Region Filing, Extraction of Connected Components, Convex Hull, Thinning, Thickening.
7. Region Extraction, Thresholding, Edge and Line Detection using gradient operators, Hough transform, Radon transform.
8. Object representation, topological attributes, Extraction of object by Boundary based descriptors.
9. Feature Extraction of object by Region based descriptors.
10. Object recognition problem with preprocessing, segmentation, feature extraction, and classification steps.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
2. Alasdair Mcandrew, "Introduction to Digital Image Processing with MATLAB", Cengage Learning Publication,2009.

CS 518 Advanced Database Management Systems Laboratory 0-0-2-1

1. Lab Exercises based on Developing objects, member functions and implementing Object oriented features in SQL
2. Lab Exercises based on Developing structured, semi-structured and unstructured data using XML. Developing programs based on XML Languages.
3. Lab Exercises based on Developing cost functions and optimizing SQL Queries
4. Lab Exercises based on developing strategies for physical database design and tuning in relational systems
5. Lab exercises based implementing horizontal fragmentation, vertical fragmentation, total replication and partial replication in distributed database systems.

HS 501 Technical Communication 2-0-0-2

1. **Process of Communication:** Clarity in pronunciation based on International Phonetic Alphabet and awareness of colloquial expressions. [7]

2. **Composition:** Letter Writing, resume writing, theme development, formats for introducing, instructing, persuading, referencing and summarizing. [7]

3. **Report Writing:** Types of reports and structure of formal reports. [4]

4. **Presentations:** Making presentations and participating in group discussions, importance of sequential presentations. [5]

5. **Miscellaneous:** Analyzing strategies and their correlation with writing patterns and editing information. [5]

CS 563 Advances in Distributed Computing 4-0-0-4

1. **Introduction:** Distributed Systems, Cluster Computing, Supercomputing, Cloud Computing. [6]
2. **Synchronous networks:** Leader election in synchronous ring networks. Leader election in rings. Basic computational tasks in general synchronous networks: leader election. [6]
3. **Fault-tolerant Systems:** Consensus, Link failures: the two generals problem. Process failures (stopping, Byzantine). Algorithms for agreement with stopping and Byzantine failures. Exponential information gathering. [6]
4. **Asynchronous distributed computing**: Formal modeling of asynchronous systems using interacting state machines (I/O automata). Proving correctness of distributed algorithms.[6]
5. **Non-fault-tolerant Systems:** Algorithms for asynchronous networks. Leader election. [4]
6. **Synchronizers**. Synchronizer applications. Synchronous vs. asynchronous distributed systems. [6]
7. **Time, clocks, and the ordering of events**: State-machine simulation. Vector timestamps. Stable property detection. Distributed termination. Global snapshots. Deadlock detection.[6]
8. **Asynchronous shared-memory systems**: The mutual exclusion problem. Mutual exclusion algorithms. Bounds on shared memory for mutual exclusion. Resource allocation. The Dining Philosophers problem. [6]
9. **Locking:** Locking algorithms, optimistic algorithms, lock-free algorithms, lazy algorithms, Load scheduling and balancing techniques. [6]

Text Books:

1. Lynch, Nancy, "Distributed Algorithms", Burlington, MA: Morgan Kaufmann, 1996. ISBN: 9781558603486.
2. George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems, Concept and Design", 3rd Edition, Pearson Education, 2005.
3. Mukesh Singhal, Niranjan G. Shivaratri, Niranjan Shivaratri, "Advanced Concepts in Operating Systems", TMH, 1994.
4. Sunita Mahajan, Seema Shah, "Distributed Computing", Oxford University Press,2010.

Reference Books:

1. Sukumar Ghosh, "Distributed Systems: An Algorithmic Approach", Chapman &Hall / CRC, 2007.
2. Pradeep K. Sinha, "Distributed Operating Systems: Concepts and Design", PHI, 2007.
3. Randy Chow, Theodore Johnson, "Distributed Operating Systems and Algorithm Analysis", Pearson, 2009.

CS 565 Advanced Compiler Construction 4-0-0-4

1. **Advanced Issues in Elementary topics:** Compiler, phases and passes, finite state machines, regular expressions and their applications to lexical analysis, implementation of lexical analyzer using LEX, CFG, bottom-up and top-down parsers, implementation of parsers using YACC. [10]

2. **Symbol Table Structure**: Storage classes, visibility and lifetime. Symbol attributes and symbol table entries, local symbol table management, and global symbol table structure, storage binding and symbolic registers. [6]

3. **Intermediate Representations**: Issues in designing intermediate languages, High level, medium level, low level and multi-level intermediate languages. Representing all intermediate languages in informal compiler algorithm notation (ICAN). [8]

4. **Code Optimization**: Introduction, early optimization, redundancy elimination. Loop optimization: Induction variable optimizations, bounds checking elimination.Procedure optimization: Tail-call optimization and Tail-recursion optimization, procedure integration, In-line expansion, leaf routine optimization and shrink wrapping. [8]

5. **Register Allocation**: Register allocation and assignment, local methods, graph coloring, priority based graph coloring. Code Scheduling: Instruction Scheduling, Speculative loads and boosting, speculative scheduling, trace scheduling, percolation scheduling. [8]

6. **Interprocedural Analysis and Optimization**: Call graph, interprocedural data flow analysis, constant propagation, alias analysis, optimizations and register allocation. [7]

7. **Automatic Code Generators**: Syntax directed technique, semantic directed parsing, tree pattern matching and dynamic programming. [5]

Text Books:

1. Steven S. Muchnik, "Advanced Compiler Design Implementation", Morgan Kauffman publishers, 2005.

Reference Books:

1. Alfred Aho, Monica Lam, Ravi Sethi, Jeffrey Ullman, "Compilers: Principles, Techniques, and Tools", Second edition, Addison-Wesley, 2006.
2. Fisher, Faraboschi, Young, "Embedded Computing - A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005.

CS 567 Bioinformatics 4-0-0-4

1. Introduction to Bioinformatics: Definition and History of Bioinformatics, Internet and Bioinformatics, Introduction to Data Mining, Applications of Data Mining to Bioinformatics Problems and Applications of Bioinformatics. [6]

2. Bioinformatics Databases: Introduction, Nucleotide sequence database - Protein sequence databases, Sequence motif databases, Protein structure databases, other relevant databases. [6]

3. Data storage and retrieval and Interoperability: Flat files, relational, object oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt).Introduction to Metadata and search; Indices, Boolean, Fuzzy, Neighboring search.The challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts.General Introduction to XML, UMLS, CORBA, PYTHON. [13]

4. Sequence Alignments and Visualization: Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example),Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal W algorithm).Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization. [12]

5. Bioinformatics Softwares: Clustal V, Clustal W 1.7, RasMol, Oligo, Molscript, Treeview, Alscript, Genetic Analysis Software, Phylip. [5]

6. Semantic Web Techniques: Bridging databases, browsing space of information, life sciences identifiers, RDF data representation. [5]

7. Bioinformatics and Distributed Computing: Java Distributed computing platform, DPRml, DSEARCH. [5]

Text Books:

1. Dan E. Krane ,"Fundamental Concepts of Bioinformatics", third edition, Pearson Education, 2009.
2. Claverie, J.M. and Notredame C. ," Bioinformatics for Dummies", Wiley Editor , January 2003.

Reference Books:

1. ShaliniSuri, "Bioinformatics", APH Publishing Corporation, 2006.

CS 569 Advanced Computer Graphics 4-0-0-4

1. **Animation:** Introduction of computer Animation, Principles of Animation, Keyframing , Kino-dynamics Planning- motion blending, skinning-skeleton animation, rigid skinning ,linear skinning, dual skinning, physics modeling-Physics-based animation, rigid body systems, articulated rigid bodies, forward and inverse dynamics. [14]

2. **Rendering:** Basic concepts of graphics models-illumination& reflection models Shading-Scanning polygons, Gourad and Phong shading ,texture mapping- bump & environmental maps , mipmaps , shading languages-vertex shedders and fragment shedders. [12]

3. **Modeling:** Representation, Using homogeneous Coordinate systems, Modeling process, terrain-representation, methods , fault formation & weather, plants modeling , animals modeling. [12]

4. **Surface Representation:** 3 dimensional object representation –polygon representations, implicit representation , Beziers ,B-splines-basis function, knot insertion, conversion , rational B-splines (NURBS)-properties and examples , evaluators, subdivision surfaces-coarse mesh and subdivision rule,types of subdivisions , Voxels . [14]

Text Books:

1. Peter Shirley, Stephen Robert Marschner, "Fundamentals of Computer Graphics" , A K Peters Limited, 2009.

Reference Books:

1. Shreiner Dave, "Opengl Programming Guide: The Official Guide To Learning Opengl", Version 2.1, 6/E , Pearson Education India, 2008.
2. Francis S. Hill, Jr., Stephen M. Kelley , "Computer Graphics: Using OpenGL" , Pearson Prentice Hall, 2008
3. James D.Foley, Andries van Dam, Steven K. Feiner, John F. Hughes , "Computer Graphics ,Principles & Practice", 3rd Edition, Pearson Prentice Hall, 2013.
4. Edward Angel , "Interactive Computer Graphics a top-Down Approach using openGL", 5th Edition Pearson Prentice Hall, 2008.

CS571 Advances in Algorithm Design 4-0-0-4

1. Pattern matching algorithms: Finite automata and regular expression, recognition of regular expression patterns, recognition of substrings, Two – way deterministic pushdown automata, position trees and substring identifiers. [11]

2. Computability theory: Turing machines, variants of Turing machines, Hilbert's problem, decidable languages, the halting problem, Un-decidable problems from language theory, mapping reducibility, the recursion theorem, decidability of logical theories, Turing reducibility, definition of information. [11]

3. Fast Fourier Transform and Polynomials: Representation of polynomials, the DFT and FFT algorithms, efficient FFT implementation, the FFT using bit operations, products of polynomials, the Schonhage – Strassen integer multiplication algorithm. [11]

4. Randomized Algorithm and Parallel Algorithm: Monte-Carlo algorithm, Las-Vegas algorithm, Game tree evaluation, De-randomization. Models for parallel computation basic techniques; Parallel matrix algorithms: matrix-vector multiplication, matrix multiplication, triangular system solution, sorting networks-parallel merging networks, zero –one principle. [8]

5. Complexity theory: Time complexity, the classes P,NP,NP complete and NP hard, Hierarchy theorems, Relativization, Circuit Complexity, approximation algorithms, probabilistic algorithms, circuit complexity, alteration, interactive proof systems, parallel computation, cryptography. [11]

Text Book:

1. Aho Alfred V., Hopcraft John E., Ullman Jefferey D. "The design and analysis of computer algorithms" Pearson education, tenth impression 2012.

Reference Books:

1. Cormen Thomas H. "Introduction to algorithms" PHI, Third edition – 2012.
2. MICHAEL SIPSER Sipser Michael, "Introduction to the theory of computation" Thomson press, Third edition 2012.
3. Brassard G.,Fundamental of Algorithmcs, Prentice-Hall of India, 2003. 4.
Horowitz E.,Computer Algorithms, Galgotia Publications, 2002.

CS 562 Mobile Cloud Computing 4-0-0-4

1. **Introduction:** Cloud, Business and IT Perspective, Virtualization, Cloud Services Requirements, Cloud And Dynamic Infrastructure, Cloud Computing Characteristics, Cloud Adoption. [8]

2. **Cloud at a Service:** Internet Software Evolution, Web Services Deliver from the Cloud, Communication-as-a-Service, Infrastructure-as-a-Service, Monitoring-as-a-Service, Platform-as-a-Service, Software-as-a-Service, Building Cloud Network. [8]

3. **Cloud Models:** Cloud Models, Cloud Characteristics, Measured Service, Security in a Public Cloud, Public Verses Private Clouds, Cloud Infrastructure Self Service. [8]

4. **Cloud Solutions:** Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management, Cloud Stack, Computing On Demand, Cloud Sourcing. [8]

5. **Cloud Offerings:** Virtual Desktop Infrastructure, Storage Cloud. [5]

6. **Cloud Virtualization technology:** Virtualization, Virtualization Benefits, Server Virtualization, Hypervisor Management Software, Virtualized Data Center. [7]

7. **Mobile Computing:** Motivation, Applications, Architectures, Platforms For Mobile Cloud Computing, Windows Phone, Android, IPhone, Popular Mobile Apps, 3G, 4G, Bluetooth, Wi-Fi. [8]

Text Books:

1. Kumar Saurabh, "Cloud Computing", Wiley India, 2011.
2. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, "Cloud Computing: Principles and Paradigms", Wiley: February 2011.
3. Michael Miller, "Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online", 1st Edition, Publisher: Pearson, 2008.

Reference Books:

1. Haley Beard, "Cloud Computing Best Practices for Managing and Measuring Processes for On Demand computing applications and data Centers in the Cloud with SLAs" , Emereo Pty Limited, July 2008.
2. Asoke Talkukder, Roopa R Yavagal, "Mobile Computing – Technology, Applications and Service Creation", Tata McGraw Hill, 2007
3. Raj Kamal, "Mobile Computing", Oxford University Press, 2007.
4. Asoke Talkukder, Roopa R Yavagal, "Mobile Computing – Technology, Applications and Service Creation", Tata McGraw Hill, 2007.

CS 564 Machine Intelligence and Robotics 4-0-0-4

1. **Introduction:** Importance of AI, Knowledge Based System, Knowledge organization & manipulation, Conceptual Introduction to LISP and other AI programming Languages. [10]

2. **Knowledge Representation:** Syntax, Semantics, Inference Rules, Non-deductive Inference methods, and representations using rules. Forward chaining and backward chaining. Fuzzy Logic & Natural languages computations. Probabilistic Reasoning. Object Oriented Representation. [10]

3. **Knowledge Organization & Manipulation:** Search & control strategies, matching techniques, knowledge organization & management, Genetic Algorithms based search techniques. [10]

4. **Robotics:** Types of Robots, spatial transformation and kinematics of open chain linkages.Mobile robots, Actuators, sensors, programming and control. Applications -motion planning, grasping and industrial automation. [12]

5. **Robot Programming:** Languages, characteristics of Languages, Position Specification, Motion Specification. Robot Program synthesis, Programming solution using VAL Robot programming Language, Artificial Intelligence, search strategies, Heuristic search, Rule based problem solving, Knowledge Representation, Robot programming using LEGO robots. [10]

Text Books:

1. R.D. Klafter, Chemieleskio, T.A. and Negin M., "Robotics Engineering an Integrated approach", Prentice Hall , 1989.
2. M. Nagenevtsky, "Artificial Intelligence –A guide to intelligent systems", Addison – Wesley , 2005.

Reference Books:

1.K.S.FU, R.C. Gonzalez, and C.S.G.Lee., "Robotics control , Sensing, Vision ,and Intelligence" , Prentice Hall , 1987.
2. J.J. Craig, "Introduction to Robotics", Addison Wesley Publishers, 2005.
3. G. Bekey, "Autonomous Robots", MIT Press, 2005.

CS 566 Natural Language Processing 4-0-0-4

1. Introduction and Language Modelling: Definition, Origin of NLP, Language and Knowledge, The challenges of NLP, Language and Grammar, NLP application, Successful early NLP systems, Information retrieval. Various grammar-based language models, statistical language models. [7]

2. Word Level Analysis and Syntactic Analysis: Introduction, Regular Expressions, Finite State Automata, Morphological Parsing, Spelling Error Detection and correction, words and words classes, Part-of-speech tagging . Context Free grammar, Constituency, Parsing, Probability Parsing. [9]

3. Semantic Analysis and Discourse Processing: Introduction, Meaning Representation, Lexical Semantics, Ambiguity, word sense Disambiguation. Cohesion, Reference Resolution, Discourse Coherence and Structure. [8]

4. Natural Language generation and Machine Translation: Introduction, Architecture of NLG systems, Generation task and representation, Problems in Machine Translations, Machine Translation approaches, Direct Machine Translation, Rule based machine translation, corpus-based MT, Semantic or knowledge based MT systems. [10]

5. Application and Lexical Resources: Speech Recognition and Synthesis, Information Retrieval Systems, Information Extraction, Automatic Text Summarization, Question-Answering; Resources: WordNet, FrameNet, Stemmers, Part-of Speech Tagger. [10]

6. NLP with Python: Introduction, Processing Raw Text, Writing Structured Program, Categorizing and Tagging words, learning to Classify Text, Analyzing Sentence Structure. [8]

Text Book:

1. Steven Bird, Ewan Klein and Edward Loper, "Natural Language Processing with Python", O' Reilly Media , 2009.

Reference Books:

1. U. S. Tiwary and Tanveer Siddiqui, "Natural Language Processing and Information Retrieval", Oxford University Press, 2008.
2. Christopher D. Manning and Hinrich Schutze," Foundation of Statistical Natural Language Processing", ISBN 0262133601, MIT Press, Cambridge, MA, 2000.

CS 568 Advanced Software Engineering 4-0-0-4

1. Introduction: Software life cycle models, Waterfall, Prototype, Evolutionary and Spiral Models, Overview of Quality Standards like ISO 9001, SEI – CMM, Software Requirements analysis & specifications, Software Project Management. [8]

2. Fundamental issues in software design: Goodness of design, cohesions, coupling, Classification of Cohesiveness & Coupling, Function-oriented design: structured analysis and design. [8]

3. Software Testing: Testing process, Design of test cases, functional testing: Boundary value analysis, Equivalence class testing, Decision table testing, Cause effect graphing, Structural testing, Path Testing, Data flow and mutation testing, Unit Testing, Integration and System Testing, Debugging, Alpha & Beta Testing, Regression Testing, Testing Tools & Standards. [10]

4. Object Oriented System Analysis and Design: Object oriented and object basics, object oriented system development cycle, process framework of OOSAD, unified approach UML, UML Diagrams: class diagram, use-case diagram, behavior diagram, OOAP, OOD and OODBMS. [8]

5. Object-Oriented Testing: Testing Object Oriented Systems overview. Broadening the View of Testing, Testing OOA and OOD Models, Object-Oriented Testing Strategies, Test Case Design for OO Software , Testing Methods Applicable at the Class Level. [8]

6. Advanced Topics in Software Engineering: Overview of Formal Methods, Cleanroom Software Engineering, Component-Based Software Engineering, Client-Server Software Engineering, Web Engineering, Reengineering, Computer-Aided Software Engineering, and the Road Ahead. [10]

Text Books:

1. R. S. Pressman, "Software Engineering – A practitioner's approach", 5th Ed., McGraw Hill Int. Ed., 2001.
2. K. K. Aggarwal & Yogesh Singh, "Software Engineering", New Age International, 2001.
3. Stephen R. Schach, "Classical & Object Oriented Software Engineering", IRWIN, 1996.

Reference Books:

1. P. Jalote, "An Integrated approach to Software Engineering", Narosa, 1991.
2. Ian Sommerville, "Software Engineering", Addison. Wesley, 1999.
3. Booch, Rumbaugh and Jacobson "The Unified Modeling Language User Guide", Addison-Wesley 2005.

CS 570 Mathematical Modeling 4-0-0-4

1. **Introduction :** Basics of modeling, mathematical models, Modeling change with difference equations, Approximate change with difference equations, solutions to dynamical systems, systems of difference equations. Modeling using proportionality, modeling using geometric similarity. [12]

2. **Model fitting and Experimental modeling :** Fitting models to data graphically, analytic method of model fitting, applying the least square criterion, choosing a best model, one term models , high order polynomial models, smoothing of low order polynomial models, cubic spline models. [10]

3. **Simulation modeling:** Introduction, simulating deterministic behavior: area under a curve, generating random numbers, simulating probabilistic behavior, queuing models. Introduction to some simulators. [10]

4. **Discrete modeling:** Probability modeling with discrete systems, linear regression, an overview of discrete optimization modeling, linear programming: geometric and algebraic solutions, simplex method. [10]

5. **Modeling with differential equations:** Introduction, population growth, graphical solutions of autonomous differential equations, numerical approximation methods, graphical solutions of autonomous systems of First order differential equations. [10]

Text Books:

1. Giordano, Weir, and Fox, "A First Course in Mathematical Modeling", 4th edition, Brooks/Cole Thomson Learning, 2009.
2. Randall James Swift, "A Course in Mathematical Modeling", Cambridge University Press, 1999.

Reference Books:

1. Edward A. Bender, "An Introduction to Mathematical Modeling", Courier Dover Publications, 2000.
2. Neville D. Fowkes, John J. Mahony, "An introduction to mathematical modeling", Wiley, 1994.