Computer Science & Engineering

M.Tech Curriculum

<table>
<tr><th colspan="4">SEMESTER-I</th></tr>
<tr><th>Courses</th><th colspan="2">Credits</th><td rowspan="7">17-20 credits</td></tr>
<tr><td>Professional and Communication Skill**</td><td>2 (S or X)</td><td>1-0-2-2</td></tr>
<tr><td>Core</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Core</td><td>4 or 5(if Lab attached)</td><td>3-0-0-4 or 3-0-2-5</td></tr>
<tr><td>Core / Elective</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Core / Elective</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Lab1*/ lab attached to a course</td><td>*2/ attached with course</td><td>0-0-2-2</td></tr>
<tr><th colspan="4">SEMESTER-II</th></tr>
<tr><th>Courses</th><th colspan="2">Credits</th><td rowspan="6">17-20 credits</td></tr>
<tr><td>Core / Elective</td><td>4 or 5(if Lab attached)</td><td>3-0-0-4 or 3-0-2-5</td></tr>
<tr><td>Elective</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Elective</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Elective or thesis credit</td><td>4</td><td>3-0-0-4</td></tr>
<tr><td>Lab1/ lab attached to a course</td><td>*2/ attached with course</td><td>0-0-2-2</td></tr>
<tr><th colspan="4">SEMESTER-III</th></tr>
<tr><th>Courses</th><th colspan="2">Credits</th><td rowspan="3">18</td></tr>
<tr><td>Thesis Credit</td><td>16</td><td>16</td></tr>
<tr><td>Graduate Seminar I</td><td>2</td><td>2</td></tr>
<tr><th colspan="4">SEMESTER-IV</th></tr>
<tr><th>Courses</th><th colspan="2">Credits</th><td rowspan="3">18</td></tr>
<tr><td>Thesis Credit</td><td>16</td><td>16</td></tr>
<tr><td>Graduate Seminar II</td><td>2</td><td>2</td></tr>
</table>

* Either lab will be attached to a core course or separate lab will be conducted

** The course can be floated either in 1st or 2nd Semester

M.TECH. IN COMPUTER SCIENCE ENGINEERING (CSE)

Semester I			
Sl. No	Course No	Course Title	Credits
1.	HS501(Core)	Professional and Communication Skills	1-0-2-2
2.	CS531(Core)	Mathematical Foundations of Computer Science	3-0-0-4
3.	CS532(Core)	Algorithms	3-0-2-5
4.	Elective I	-	3-0-0-4
5.	Elective II	-	3-0-0-4
6.	CS532L	Lab Attached with CS532(Core)	
Semester II			
1.	Elective III	-	3-0-0-4
2.	Elective IV	-	3-0-0-4
3.	Elective V	-	3-0-0-4
4.	CS699	M.Tech Thesis	4
5.	CS533	Lab 2 (Data Analytics Lab)	0-0-2-2
Semester III			
1.	CS598	Graduate Seminar I	2
2.	CS699	M.Tech Thesis	16
Semester IV			
1.	CS599	Graduate Seminar II	2
2.	CS699	M.Tech Thesis	16

Electives

1.	CS534	Research Methods in Computer Science	3-0-0-4
2.	CS601	Game Theory and Networks	3-0-0-4
3.	CS602	Social Network Analysis	3-0-0-4
4.	CS603	Queueing Theory	3-0-0-4
5.	CS604	Model Thinking	3-0-0-4
6.	CS608	Mobile and Wireless Networks	3-0-0-4
7.	CS609	Wireless Sensor Networks	3-0-0-4
8.	CS615	Machine Learning	3-0-0-4
9.	CS616	Pattern Recognition	3-0-0-4
10.	CS617	Basics of Deep Learning	3-0-0-4
11.	CS618	Soft Computing	3-0-0-4
12.	CS619	Data Mining and Data Warehousing	3-0-0-4
13.	CS620	Natural Language Processing	3-0-0-4
14.	CS621	Image Processing	3-0-0-4
15.	CS622	Computer Vision	3-0-0-4
16.	CS623	Multimedia Processing	3-0-0-4
17.	CS624	Medical Image Processing	3-0-0-4
18.	CS625	Biometric Technologies and Applications	3-0-0-4
19.	CS626	Content Based Image Retrieval	3-0-0-4
20.	CS627	Image Reconstruction	3-0-0-4
21.	CS631	Parallel Algorithms	3-0-0-4
22.	CS632	Advanced Algorithms	3-0-0-4
23.	CS633	Approximation Algorithms	3-0-0-4

24.	CS634	Randomized Algorithms	3-0-0-4
25.	CS635	Computational Geometry	3-0-0-4
26.	CS636	Optimization Theory and Applications	3-0-0-4
27.	CS637	Mesh Free Computations	3-0-0-4
28.	CS641	Principles of Programming Languages	3-0-0-4
29.	CS642	Object Oriented Analysis and Design	3-0-0-4
30.	CS651	Fuzzy Sets, Logic and Applications	3-0-0-4
31.	CS652	Statistical Methods in Computer Science	3-0-0-4
32.	CS653	Artificial Intelligence	3-0-0-4
33.	CS654	Big Data Analytics	3-0-0-4
34.	CS655	Cloud Computing	3-0-0-4
35.	CS656	Basic of Bioinformatics	3-0-0-4
36.	CS671	Quantitative Methods in Software Engineering	3-0-0-4
37.	CS672	Software Testing and Quality Assurance	3-0-0-4
38.	CS673	Human Computer Interaction	3-0-0-4
39.	CS674	Distributed Systems	3-0-0-4
40.	CS681	Coding Theory	3-0-0-4
41.	CS682	Cyber Security	3-0-0-4
42.	CS683	Visual Cryptography and Data Hiding	3-0-0-4
43.	CS684	Cryptography and Network Security	3-0-0-4
44.	CS691	Advanced Computer Architecture	3-0-0-4

Electives in Modular form

1.	EM601a	Advanced Topics in Computer Architecture	2-0-0-2
2.	EM601d	Parallel Processing	1-0-0-1
3.	EM601h	Dependable Computing	1-0-01
4.	EM602d	Artificial Intelligence and its Applications	1-0-0-1
5.	EM602e	Bayesian Classifiers	2-0-0-2
6.	EM605f	Coding Theory	1-0-0-1
7.	EM605h	Network Flow Optimization	2-0-0-2
8.	EM605i	External Memory Algorithms	2-0-0-2
9.	EM607a	Design of Extensible Application in Java	1-0-0-1
10.	EM608a	Modelling and Simulation	1-0-0-1
11.	EM608b	Graphical Models	2-0-0-2
12.	EM609b	Public Key Cryptography	1-0-0-1
13.	EM609c	Speech and Music Signal Processing	1-0-0-1
14.	EM609e	Cyber Security	1-0-0-1
15.	EM609g	Computational Number Theory and Cryptography	2-0-0-2
16.	EM609h	Elementary Number Theory	2-0-0-2
17.	EM668g	Software Quality Assurance	1-0-0-1

Course Title	**:**	Mathematical Foundations of Computer Science			
Course Code	**:**	CS531	**Course Type**	**:**	Core
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	MTech/PhD			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	After reading this course the student gains competence in mathematical concepts frequently used in computer science applications.			

Course Details:

Module 1: Review of sets, functions, relations. Number theory: division algorithm, Euclid's algorithm, fundamental theorem of arithmetic, Chinese remainder theorem. Combinatorics: permutations, combinations, partitions, recurrences, generating functions. **[8H]**

Module 2: Graph Theory: isomorphism, complete graphs, bipartite graphs, matchings, colourability, and planarity. **[8H]**

Module 3: Review of algebraic Structures: semigroups, groups, subgroups, homomorphisms, rings, integral domains, fields, lattices and Boolean algebras. **[7H]**

Module 4: Review of Linear algebra: system of linear equations, matrices, vector spaces, linear transformations, Eigenvectors, diagonalization. **[7H]**

Module 5: Probability: Conditional probability, random variables, probability distributions, Markov's inequality, Chebyshev and Chernoff Bounds. Statistical Inference - Foundation for Inference, Central Limit Theorem, Sampling Distributions, Confidence Interval, Hypothesis Testing, Inference for Numerical and Categorical data. **[10H]**

Text/Reference books:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw Hill, 1999.
2. Jean-Paul Tremblay, R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill, Indian Edition, 2001.
3. C. L. Liu, D. Mohapatra, Elements of Discrete Mathematics: A Computer Oriented Approach, McGraw Hill, Indian Edition, 2012.
4. T. Veerarajan, Discrete Mathematics with Graph Theory and Combinatorics, McGraw Hill, 2006.
5. R. E. Walpole, R.H. Myers, S. L. Myers, K. E. Ye, Probability and Statistics for Engineers and Scientists, Pearson, 2017.

Course Title	**:**	Algorithms			
Course Code	**:**	CS532	**Course Type**	**:**	Core
Contact Hours	**:**	L- 3 T- 0 P- 2	**Credit**	**:**	5
Program/Semester	**:**	M. Tech/PhD / Semester-I			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Lab (20%)			
Learning Objective	**:**	This course will cover the algorithm design paradigms and the intractable problems with their approximation algorithms. The students will also learn different models of computation and their uses in algorithm designing.			

Course Details:

Module 1: Performance of algorithms: space and time complexity; Design techniques: greedy method, divide-and-conquer, dynamic programming; Sorting and searching; Graph Algorithms: Shortest path, Spanning trees, Network flow. **[15H]**

Module 2: Data Structures: Priority Queues: lists, heaps, binomial heaps, Fibonacci heaps**. [10H]**

Module 3: Computational intractability, Approximation algorithms**. [10H]**

Module 4: A selection of advanced topics: Randomized Algorithm, Parallel algorithm, External Memory algorithm. **[5H]**

Text/Reference books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, Third Edition, MIT Press, 2009.
2. J. Kleinberg and E. Tardos, Algorithm Design, Addison Wesley, 2005.
3. Aho, J E Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley, 1974.
4. S Sahni, Data Structures, Algorithms and Applications in C++, McGraw Hill, 2001.
5. M. T. Goodrich and R. Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, John Wiley & Sons, 2001.

Course Title	**:**	Data Analytics Lab			
Course Code	**:**	CS533L	**Course Type**	**:**	Core (Lab 2)
Contact Hours	**:**	L- 0 T- 0 P- 2	**Credit**	**:**	2
Program/Semester	**:**	M. Tech/PhD / Semester-I			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Lab (60%), End term (40%)			
Learning Objective	**:**	This course will cover the algorithm design paradigms and the intractable problems with their approximation algorithms. The students will also learn different models of computation and their uses in algorithm designing.			
Course Details:					
Module 1: Introduction to Programming Environment, Variables and Expressions, Loops and Conditional Statements, Introduction to datatypes (Lists, Dictionaries, Tuples, strings), Functions, Scope, Recursion, Expressions. Descriptive Statistics like mean, mode, median, standard deviation, five-point summary, Scatter plots. Data Distributions – Binomial, Normal, Poisson. Standard score and Probability calculations. Regression, Correlation, Co-variance, coefficient of regression (r), coefficient of determination (R2). Inferential Statistics, Confidence Interval, hypothesis testing, type-I and type-II errors, p-values, significance levels, Test of significance. **[20H]**					
Text/Reference books: 1. For the lab exercises, programming platforms like Python, R, Matlab, Java, and similar will be used.					

Course Title	:	Research Methods in Computer Science			
Course Code	:	CS534	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (0%), End term (40%), Project (30%)			
Learning Objective	:	1. To introduce research methodologies in CS to students going to peruse research in CS. 2. To understand the strengths and weakness of each of these methods. 3. How to choose suitable method (s) for the investigations. 4. How to carry out these investigations. 5. How to deal with the threats associated with these investigations. 6. Reporting the results of these investigations.			

Course Details:

Module 1: Introduction to Research and the research Process, Quantitative and Qualitative research methods, Criteria for selecting research methods, literature review, research questions and hypotheses, surveys case studies, Controlled Experiments, Ethnography and Action Research, Validity threats. **[10H]**

Module 2: Introduction to Quantitative Research, Study Designs, Elements and Methods, Analysis and interpretation of Quantitative Data Descriptive and Influential Statistics, Sampling and Data Collection, sampling distribution, parameter, Estimation, confidence interval and Hypothesis Testing , correlation and regression , Tests of singnificance, test of difference of mean and proportions, t-tests, ANOVA Chi-square Tests, Validity Threats. **[10H]**

Module 3: Qualitative Methods, Study Designs, Elements, and Methods, The nature and types of qualitative research, Data collection methods- primary and secondary sources, Types of data analysis methods, Validity threats. **[10H]**

Module 4: Introduction to Mixed Methods Research, Study Designs and Method, Writing research proposal, purpose nature and evaluation, content and format, Validity threats. **[10H]**

Text/Reference books:

1. John W. Creswell, Research Design. Qualitative, Quantitative, and Mixed Methods Approaches, Fourth Edition, SAGE Publication, 2014.
2. Wayne C. Booth, Gregoty G. Colomb, Joseph M. Williams, Joseph Bizup, William T. fitzGerald, The Craft of Research, Fourth Edition, The University of Chicago Press, 2016.
3. Kothari, Chakravanti Rajagopalachari, Research methodology: Methods and techniques, New Age International, 2004.

Course Title	**:**	Game Theory and Networks			
Course Code	**:**	CS601	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	To understand relation between Game Theory and Networks			

Course Details:

Module 1: Nash Equilibrium: Theory Strategic games; the Prisoner's Dilemma, Bach or Stravinsky, Brass Paradox, Matching Pennies, The Stag Hunt, Nash Equilibrium, Best response functions, Dominated actions, Equilibrium in single population. Mixed Strategy Equilibrium Introduction, Mixed strategy Nash equilibrium, The formation of players' beliefs, finding all mixed strategy Nash equilibria, Games in which each player has a continuum of actions. **[10H]**

Module 2: Extensive Games with Perfect Information Introduction, Strategies and outcomes, Nash equilibrium, Subgame perfect equilibrium, Finding subgame perfect equilibria of finite horizon games, Stackelberg's model of duopoly. **[10H]**

Module 3: Repeated Games: The Prisoner's Dilemma, General Result. Incentives and Pricing in Communications Networks: Large Networks, Pricing and Resource Allocation, Alternative Pricing and Incentive Approaches. **[10H]**

Module 4: Incentives in Peer-to-Peer Systems: The p2p File sharing games, Reputation, Barter based system, Currency, Hidden action in p2p systems. Manipulation-Resistant Reputation Systems: Why Are Reputation Systems Important?, The Effect of Reputations, Whitewashing, Eliciting Effort and Honest Feedback, Reputations Based on Transitive Trust. **[10H]**

Text/Reference books:

1. Noam Nisan, Tim Roughgarden, Eva Tardos, and Vijay V. Vazirani, Algorithmic Game Theory, Cambridge University Press, New York, 2007.
2. Osborne, M. J., An Introduction to Game Theory, Oxford University Press, New York, 2004.
3. Kevin Leyton-Brown, Yoav Shoham, Essentials of Game Theory: A Concise, Multidisciplinary Introduction, Morgan & Claypool Publishers, 2008.
4. D. Fudenberg and J. Tirole, Game Theory, The MIT Press, Cambridge MA, 1992.

Course Title	:	Social Network Analysis			
Course Code	:	CS602	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	After acquiring basic tools needed to analyze and model networks through computers, the students will explore increasingly complex social, infrastructure, information, and biological networks.			

Course Details:

Module 1: Introduction: Basic network properties: nodes, edges, adjacency matrix, node degree, connected components, giant component, average shortest path, diameter. **[10H]**

Module 2: Social Network models: Erdos-Renyi, Watts Strogatz and Barabasi-Albert model. The Small World Phenomena and Decentralized search in small-world. Social network analysis tools: networks X, UNCIENT, Gephi, Pajek, and Graphviz. **[10H]**

Module 3: Network centrality: between-ness, closeness, eigenvector centrality, Network Algorithms: Algorithms for degrees and degree distributions, Clustering coefficients, shortest path in network with varying edge lengths. Strength of weak ties and Community structure in networks: Network community detection: Modularity optimization and spectral clustering coefficients, overlapping communities in networks. **[10H]**

Module 4: Information Retrieval: link Analysis: HITS and Page Rank. Epidemic models over Networks: SI, SIS, SIR, SIRS models, Percolation and Network Resilience. **[10H]**

Text/Reference books:

1. Easley, David, and J. Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.
2. Mark Newman, Networks: An Introduction, Oxford University Press, 2010.
3. Robert A. Hanneman, Mark D. Riddle, An Introduction to Social Network Methods, 2005.
4. M.E. J. Newman, The structure and function of complex networks, SIAM Review 45, 167-256, 2003.

Course Title	:	Queuing Theory			
Course Code	:	CS603	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	To understand the queuing theory.			

Course Details:

Module 1: Preliminaries: System of Flows, The speciation and measure of queuing systems, Notation and structure for basic queuing systems, Definition and classification of stochastic processes, Discrete time Markov chains, Continuous time Markov chains, Birth-death processes. **[10H]**

Module 2: Birth and Death Systems in equilibrium: General equilibrium solution, M/M/1: The classical queuing system. Discouraged arrivals, M/M/∞: Responsive servers, M/M/m (The m-server case), M/M/1/k (Finite storage). **[10H]**

Module 3: The Queue M/G/1: M/M/m/m (m-server Loss system), M/M/1/M (Finite customer population- Single server), M/M/∞/M (Finite customer population- Infinite server), The M/G/1 system, The paradox of residual life. **[10H]**

Module 4: The embedded Markov Chain, The transition probabilities, The mean queue length, Distribution of Number in systems, Distribution of waiting time, The busy period and its duration, The number served in busy period, From busy period to waiting times. **[10H]**

Text/ Reference books:

1. Leonard Kleinrock, Queueing Systems Volume 1: Theory, Wiley, 1976.
2. Donald Gross, J. F. Shortle, J. M. Thompson, Carl M. Harris, Fundamentals of Queueing Theory, Fourth Edition, Wiley, 2008.
3. K. S. Trivedi, Probability and Statistics with Reliability Queueing and Computer Science Applications, Second Edition, Wiley, 2001.

Course Title	:	Model Thinking			
Course Code	:	CS604	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The objective of the course is to expose the students to the general principles of model thinking, and how models are evolved using a philosophical, logical and learning approach.			

Course Details:

Module 1: Why Model & Segregation/Peer Effects, Aggregation & Decision Models, Thinking Electrons: Modeling People & Categorical and Linear Models. **[10H]**

Module 2: Tipping points & economic growth, Diversity and innovation & Markov processes, Lyapunov functions & coordination and culture. **[10H]**

Module 3: Path dependence & networks, Randomness and random walks & Colonel Blotto, Prisoners' dilemma and collective action & mechanism design. **[10H]**

Module 4: Learning models: Replicator dynamics & prediction and the many model thinker. **[10H]**

Text/ Reference books:

1. Mikael Krogerus, Roman Tschäppeler, Jenny Piening, Philip Earnhart, The Decision Book - 50 Models for Strategic Thinking, W. W. Norton & Company, 2012.
2. Alexander Osterwalder and Yves Pigneur, Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley, 2010.
3. Mikael Krogerus and Roman Tschäppeler, The Change Book: Fifty Models to Explain How Tthings happen, Profile Books Ltd, Jan 2013.
4. Donella H. Meadows, Thinking in Systems: A Primer, Chelsea Green Publishing, 2015.

Course Title	:	Mobile and Wireless Networks			
Course Code	:	CS608	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	After completing this course, the student will learn the enabling technology in the wireless networking along with components and subsystems used in wireless networking.			

Course Details:

Module 1: (Basic of wireless communication & channel) An Overview of Wireless Systems: Wireless History, A taxonomy of wireless networks, Cellular Generations (from1G to 4G), Current & Future Wireless Technologies, Trends. Radio Propagation and Interference: Radio wave propagation, Multi-path characteristic of radio wave, Short/long term fading, Indoor and Outdoor propagation models. **[10H]**

Module 2: (Multiple Radio Access & Multiple Division Techniques for Traffic Channels)
Modulation techniques: Digital Modulation in Modern Wireless Systems (QPSK, DQPSK, p/4 DQPSK, n-QAM, OFDM). Multiple Access Techniques: Contention-Based (Random-based) Protocols (ALOHA, CSMA), Reservation based Protocols (FDMA, TDMA, CDMA), Fundamental of SC-FDMA and OFDMA, FHSS, DSSS. **[10H]**

Module 3: (Mobile Wireless Networks) Cellular concept: Basic principles of cellular systems, e.g., Cell layout, Planning, Interference. Traffic Channel Allocation & Mobility: Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA), Hybrid Channel Allocation (HCA), Mobile IP. **[10H]**

Module 4: (Wireless LAN & PAN) Wireless LAN: Operation of IEEE 802.11 Wireless LAN, incl. CSMA/CA, RTS/CTS, power management, 802.11a/b/g/n, 802.11e. Wireless PAN: Overview of operation of low-power wireless systems based on IEEE 802.15.1 (Bluetooth) and IEEE 802.15.4 (Zigbee). Introduction to WiMAX and LTE. **[10H]**

Text/ Reference books:

1. Dharma P. Agrawal, Qing-An Zeng, Introduction to Wireless and Mobile Systems, Third Edition, Cengage learning, 2015.
2. Kaveh Pahlavan, Principles of Wireless Networks: A Unified Approach, Second Revised Edition, John Wiley & Sons, Inc., 2011.
3. Garg, Wireless Communications and Networks, Morgan Kaufmann, 2010.
4. T. S. Rappaport, Wireless Communications-Principles and Practice, Second Edition, Pearson Education, 2002.
5. William Stallings, Wireless Communications and Networks, Second Edition, Pearson, 2005.

Course Title	:	Wireless Sensor Networks			
Course Code	:	CS609	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	After completing this course, the students will learn various hardware and software platforms that exist for sensor networks. They will also learn various network level protocols for MAC, routing, time synchronization, aggregation consensus and distributed tracking.			

Course Details:

Module 1: Characteristics of WSN: Characteristic requirements for WSN, Challenges for WSNs, WSN vs Adhoc Networks. Sensor node architecture, Commercially available sensor nodes (Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspot), Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations. **[10H]**

Module 2: Medium Access Control Protocols: Fundamentals of MAC protocols, Low duty cycle protocols and wakeup concepts, Contention based protocols, Schedule-based protocols, SMAC, BMAC, Traffic-adaptive medium access protocol (TRAMA), The IEEE 802.15.4 MAC protocol. **[10H]**

Module 3: Routing Protocols: Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping, Data centric Routing, SPIN, Directed Diffusion, Energy aware routing, Gradient-based routing, Rumor Routing (COUGAR, ACQUIRE), Hierarchical Routing (LEACH, PEGASIS), Location Based Routing (GF, GAF, GEAR, GPSR), Real Time routing Protocols (TEEN, APTEEN, SPEED, RAP). **[10H]**

Module 4: Data Gathering Protocols and Applications Of WSN: Data aggregation, data aggregation operations, Aggregate Queries in Sensor Networks, Aggregation Techniques, TAG, Tiny DB, Applications of WSN: WSN Applications, Home Control, Building Automation, Industrial Automation, Medical Applications, Reconfigurable Sensor Networks, Highway Monitoring, Military Applications, Civil and Environmental Engineering Applications, Wildfire Instrumentation, Habitat Monitoring, Nanoscopic Sensor Applications, Case Study: IEEE 802.15.4 LR-WPANs Standard, Target detection and tracking, Contour/edge detection, Field sampling. **[10H]**

Text/ Reference books:

1. Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, Ltd, 2005.
2. Kazem Sohraby, Daniel Minoli and Taieb Znati, Wireless Sensor Networks Technology, Protocols, and Applications, John Wiley & Sons, 2007.
3. Anna Ha´c, Wireless Sensor Network Designs, John Wiley & Sons, 2003.

Course Title	:	Machine Learning			
Course Code	:	CS615	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	In this course students will learn to train the machine using different machine algorithms to solve the real-world prediction problems.			

Course Details:

Module 1: Learning Problem, Designing a Learning System, Types of Learning. Supervise Learning: Linear and Logistic regression, Decision Tree Learning. **[10H]**

Module 2: Instance-Based Learning, kNN and CBR, Bayesian Learning, Naive Bayes Classifier, Artificial Neural Network (ANN), SVM. **[10H]**

Module 3: Unsupervised Learning: Mixture Models and EM, Clustering, K-Means, DBSCAN, Hierarchical clustering, Association Rule Mining, Dimensionality Reduction. **[10H]**

Module 4: Performance Evaluation, Confusion Metrics, Evaluating Hypotheses, Confidence Interval, Hypothesis Testing Ensemble Learning Bagging and Boosting Formulating. Computational Learning Theory, Issues and practical advice in Machine Learning. **[10H]**

Text/ Reference books:

1. Tom Mitchell. Machine Learning, McGraw Hill, 1997.
2. Chris Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
3. Stephen Marsland, Machine Learning an Algorithmic Perspective, Chapman and Hall/CRC, 2014.
4. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, Foundations of Machine Learning (Adaptive Computation and Machine Learning Series), MIT, 2012.

Course Title	:	Pattern Recognition			
Course Code	:	CS616	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The objective of this course is to introduce basics of pattern recognition with its applications to computer vision, which will help students to develop real time applications such as biometrics, medical imaging etc.			

Course Details:

Module 1: Introduction: Feature extraction and Pattern Representation, Concept of Supervised and Unsupervised Classification, Introduction to Application Areas. Statistical Pattern Recognition: Bayes Decision Theory, Minimum Error and Minimum Risk Classifiers, Discriminant Function and Decision Boundary, Normal Density, Discriminant Function for Discrete, Features, Parameter Estimation, and Maximum Likelihood Estimation. **[10H]**

Module 2: Dimensionality Problem: Dimension and accuracy, Computational Complexity, Dimensionality Reduction, Fisher Linear Discriminant, Multiple Discriminant Analysis. Nonparametric Pattern Classification: Density Estimation, Nearest Neighbour Rule, Fuzzy Classification. **[10H]**

Module 3: Linear Discriminant Functions: Separability, Two Category and Multi Category Classification, Linear Discriminators, Perceptron Criterion, Relaxation Procedure, Minimum Square Error Criterion, Widrow-Hoff Procedure, Ho-Kashyap Procedure, Kesler's Construction. **[10H]**

Module 4: Neural Network Classifier (introduction), Hopfield Network, Fuzzy Neural Network. Time Varying Pattern Recognition: First Order Hidden Markov Model, Evaluation Decoding, Learning. **[10H]**

Text/ Reference books:

1. Richard O. Duda, Peter E. Hart, David G. Strok, Pattern Classification, Second Edition, Wiley-Interscience, 2000.
2. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3. Tom M. Mitchell, Machine Learning, McGraw Hill Education, 1997.
4. S. Theodoridis, K. Koutroumbas, Pattern Recognition, Fourth edition, Academic Press, 2008.

Course Title	:	Basics of Deep Learning			
Course Code	:	CS617	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	With the exposure of deep learning methodology, students will learn its potential application in various areas like Computer Vision and Natural Language Processing.			

Course Details:

Module 1: Introduction-Feedforward Neural networks, Gradient Descent and the back propagation algorithm, Unit saturation, aka the vanishing gradient problem, and ways to mitigate it, Relu Heuristics for avoiding bad local minima, Heuristics for faster training, Nestors accelerated gradient descent, Regularization. Dropout. **[10H]**

Module 2: Convolutional Neural Networks Architectures, convolution/Pooling layers, Recurrent Neural Networks, LSTM, GRU, Encoder Decoder architectures. Deep Unsupervised learning Autoencoders (standard, sparse, denoising, contractive, etc.), Variational Autoencoders, Adversarial Generative Networks, Autoencoder and DBM. **[10H]**

Module 3: Applications of Deep Learning to Computer vision, Image segmentation, Object detection, Automatic image captioning, Image generation with Generative adversarial networks, Video to text with LSTM models, Attention models for computer vision tasks. Applications of Deep Learning to NLP, Vector Space Models of Semantics Word Vector Representations: Continuous Skip-Gram Model, Continuous Bag-of-Words model (CBOW), Glove, Evaluations and Applications in word similarity, analogy reasoning. **[10H]**

Module 4: Named Entity Recognition, Opinion Mining using Recurrent Neural Networks, Parsing and Sentiment Analysis using Recursive Neural Networks, Sentence Classification using Convolutional Neural Networks Dialogue Generation with LSTMs, Applications of Dynamic Memory Networks in NLP, Recent Research in NLP using Deep Learning: Factoid question answering, Similar question detection, Dialogue topic tracking, Neural Summarization, Smart Reply. **[10H]**

Text/ Reference books:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.
2. Ohlsson, Stellan, Deep learning: How the mind overrides experience, Cambridge University Press, 2011.
3. Li Deng, Dong Yu, Deep Learning: Methods and Applications, NOW Publishers, 2014.
4. Nikhil Buduma and Nicholas Locascio, Fundamentals of Deep Learning: Designing Next-Generation Artificial Intelligence Algorithms, O'Reilly Media, 2017.

Course Title	:	Soft Computing			
Course Code	:	CS618	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The course is aimed at introducing some of the most extensively used soft computing techniques in engineering applications. After learning these techniques, the student will be able to understand the theory behind some of the standard soft computing tools available for applications and will be able to write his/her own code also for specific application.			

Course Details:

Module 1: Introduction to Computing: Evolution of Computing, Basics of Soft Computing. Conventional AI and Computational Intelligence, Machine Learning Basics. **[8H]**

Module 2: Neural Networks: Introduction to neural networks, Neural network architecture, Learning methods, Architecture of a back propagation network, Applications. **[8H]**

Module 3: Fuzzy Logic: Crisp and Fuzzy sets, membership functions, Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations, Propositional and predicate logic, fuzzy mapping rules and implications, Applications. **[8H]**

Module 4: Nature Inspired Algorithms: Introduction, Genetic algorithms, Differential evolution, Particle swarm optimization, Cuckoo search. **[10H]**

Module 5: Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms. **[6H]**

Text/ Reference books:

1. N.P. Padhy and S.P. Simon, Soft Computing: With Matlab Programming, Oxford University Press, 2015.
2. K.H.Lee, First Course on Fuzzy Theory and Applications, Springer-Verlag, 2004.
3. D. E. Goldberg, Genetic Algorithms: Search, Optimization and Machine Learning, Addison Wesley, 1989.
4. S. Rajasekaran and G.A.Vijaylakshmi Pai, Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India, 2003.
5. J.S.R. Jang, C.T. Sun and E. Mizutani, Neuro-Fuzzy and Soft Computing, Prentice Hall of India, 2004.

Course Title	:	Data Mining and Data Warehousing			
Course Code	:	CS619	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	This course will cover basic understanding of data mining preprocessing steps and techniques. Topic will include association rule mining, supervised leaning, and unsupervised algorithm. It also provides an application of data mining in the field of web mining and text mining.			

Course Details:

Module 1: Introduction to Data Mining, Data Mining Goals, Stages of the Data Mining Process, Data Mining Techniques, Knowledge Representation Methods. Data Warehouse and DBMS, Multidimensional data model, OLAP operations, Data warehouse architecture. Data cleaning, Data transformation, Data reduction, Discretization and generating concept hierarchies, Experiments with Weka 3 Data Mining System-filters, discretization**. [10H]**

Module 2: Data mining knowledge representation, Task relevant data, Background knowledge, Interestingness measures, Representing input data and output knowledge, Visualization techniques. Attribute-oriented analysis, Attribute generalization, Attribute relevance, Class comparison, Statistical measures. **[10H]**

Module 3: Association rules Mining, Motivation and terminology, Example: mining weather data, Basic idea: item sets, Generating item sets and rules efficiently, Correlation analysis, frequent patterns without candidate generations, multilevel association rule mining. Overview of mining algorithms such as decision tree, support vector machine, clustering, fuzzy algorithms, Evaluating the Accuracy of a mining algorithms. **[10H]**

Module 4: Text mining, Automatic keyword extraction from individual documents, Textual Information to Numerical Vectors, Events and trends detection in text streams, Content-based spam email classification, Text mining software. Web mining**,** Information retrieval and web search, Web spamming, Mining the social web, Web crawling, Web usage mining, application of mining in multimedia, Web data mining software. **[10H]**

Text/ Reference books:

1. Alex Berson, Stephen J. Smith, Data Warehousing, Data Mining, & OLAP, First Edition, Tata Mcgraw-Hill, 2004.
2. Pang Ning Tan, Michael Steinbach, and Vipin Kumar, Introduction to Data Mining, First Edition, Pearson Education 2005.
3. Ian H. Witten, Eibe Frank, and Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Third Edition, Morgan Kaufmann 2011.
4. Margaret H. Dunham, Data Mining: Introductory and Advanced Topics, Pearson Education 2003.
5. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents and Usage Data, Springer, 2007.
6. Ashok Srivastava, Mehran Sahami, Text Mining: Classification, Clustering, and Applications, CRC Press 2009.

Course Title	:	Natural Language Processing			
Course Code	:	CS620	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The objective of this course is to give hand on experience on natural language text processing with applications to parts-of-speech tagging, parsing, tagging and so on.			

Course Details:

Module 1: Basic Text Processing, Regular expression, sentence segmentation, word stemming. Language modeling problem, Hidden Markov models, N-gram models, parameter estimation, model evaluation, perplexity, smoothing. **[10H]**

Module 2: Text classification, Naïve Bayes and multinomial Naïve Bayes, Evaluation, Sentiment Analysis POS Tagging problems, Viterbi Algorithm for HMM, NER. **[10H]**

Module 3: The parsing problem, CFG and Probabilistic context-free grammars (PCFG), CKY Parsing algorithm, weaknesses of PCFGs, Lexicalized PCFG. Information Retrieval, Term-Document Incidence Matrices, The Inverted Index, Introducing Ranked Retrieval, Term Frequency Weighting, Inverse Document Frequency Weighting, TF-IDF Weighting. **[10H]**

Module 4: Log-linear models, and their application to NLP problems like tagging, parsing Unsupervised and semi-supervised learning in NLP. **[10H]**

Text/ Reference books:

1. Jurafsky and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008.
2. Chris Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, MIT Press. Cambridge, MA: May 1999.
3. Christopher D. Manning, Foundations of statistical natural language processing, MIT Press Cambridge, 1999.
4. Anne Kao, Steve R. Poteet, Natural language processing and text mining, Springer, 2006.

Course Title	:	Image Processing			
Course Code	:	CS621	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	Understand image formation and the role human visual system plays in perception of gray and color image data. Get broad exposure to and understanding of various applications of image processing in industry, medicine, and defence.			

Course Details:

Module 1: Digital Image Fundamentals: Image sensing, acquisition, sampling and quantization, basic relationships between pixels. Image Enhancement in Spatial Domain: Gray level transformation, histogram processing, smoothing and sharpening Spatial Filters. **[8H]**

Module 2: Image Transforms: Fourier transform and their properties, Fast Fourier transform, Other transforms, image enhancement in frequency domain. **[8H]**

Module 3: Color Image Processing, Image Restoration, Image Compression. **[8H]**

Module 4: Wavelets and Multiresolution Analysis: Introduction to wavelets, scaling functions and subspaces, Subband coding, Subband decomposition of images, Continuous and Discrete wavelet transforms. Various morphological operators and their use in different applications. **[8H]**

Module 5: Image Segmentation: edge detection, Hough transform, region based segmentation, Representation and Description: Object representation, boundary based descriptors, region based descriptors (texture and shape features). **[8H]**

Text/Reference books:

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Third Edition, Pearson, 2012.
2. M Sonka, V Hlavac, R Boyle, Image Processing, Analysis, and Machine Vision, Third Edition, Thomson Engineering, 2007.
3. W. K. Pratt, Digital Image processing, Third Edition, John Wiley & Sons Inc., 2001.
4. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson Education, 2006.

Course Title	:	Computer Vision			
Course Code	:	CS622	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	To introduce students with theoretical and practical aspects of computing with images. Students will learn necessary theory and skills for automatic analysis of digital images with the basics of 2D and 3D Computer Vision.			

Course Details:

Module 1: Introduction to Computer Vision, Image Formation and Representation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc., Camera Models, Camera Calibration, Epipolar Geometry, Stereo & Multi-view Reconstruction. **[10H]**

Module 2: Basic image processing operations, Convolution and Filtering. Feature Extraction: Edges - Canny, LOG, DOG, Line detectors - Hough Transform, Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis-Image Pyramids and Gaussian derivative filters. **[10H]**

Module 3: Image Segmentation: Contour based, Region Growing, Graph based, Mean-Shift, Graph cuts. Object Recognition: Structural Approaches, Model-based Approaches, Appearance and Shape-based Approaches, Probabilistic Paradigms. Performance evaluation parameters. **[10H]**

Module 4: Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. Vision Applications: CBIR, CBVR, Security and Surveillance (Activity Recognition, Biometrics etc.), Medical image processing etc. **[10H]**

Text/Reference books:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Ltd, 2011.
2. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003.
5. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
6. V.S. Nalwa, A Guided Tour of Computer Vision, Addison-Wesley, 1993.
7. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Third Edition, Pearson, 2012.

Course Title	:	Multimedia Processing			
Course Code	:	CS623	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The objective of the course is to introduce the basics of multimedia systems and processing. Students will be exposed to image compression and decompression. They will also learn about audio and video coding techniques, and standards.			

Course Details:

Module 1: Introduction to Multimedia Systems and Processing, Computer Representation of Audio, Image, and Video, Image compression and decompression systems, Redundancies and their Classification, Entropy and Information Theory, Lossless and lossy image compression, Quality measures of reconstructed images. **[8H]**

Module 2: Lossless Compression (Run Length Encoding, Variable Length Coding, and Dictionary-Based Coding techniques): Huffman coding, Shannon's Coding Theorem for noiseless channels, Arithmetic and LempelZiv coding. Lossy Compression: Uniform and non-uniform quantization, Rate-distortion function and Source Coding Theorem, Delta modulation and DPCM, Transform coding and DCT, JPEG. **[8H]**

Module 3: Multiresolution Analysis: Introduction to wavelets, scaling functions and ladder of subspaces, Subband coding, Conditions for perfect reconstruction, Subband decomposition of images, Discrete wavelet transform. Embedded wavelet coding, JPEG-2000. **[8H]**

Module 4: Video Coding and Motion Estimation: Basic building blocks and temporal redundancy, Motion estimation algorithms, Video coding standards –MPEG-4 and H.264. Audio Coding: Basic of Audio Coding, transform and filter banks, Format and encoding, Psychoacoustic models. **[8H]**

Module 5: Multimedia Synchronization: Basic definitions and requirements, Time stamping and pack architecture, References model and specification, Packet architectures and audio-video interleaving, Playback continuity. Video Indexing and Retrieval: Content based image retrieval, Video content representation, Video sequence query processing. **[8H]**

Text/Reference books:

1. P. Havaldar and G. Medioni, Multimedia Systems - Algorithms, Standards and Industry Practices, Cengage Learning, 2009.
2. R. Steinmetz and K. Nahrstedt, Multimedia Fundamentals: Media Coding and Content Processing, Second Edition, Prentice Hall, 2002.
3. NPTEL Course on Multimedia Processing by IIT Kharagpur.
4. Coursera – Course on Fundamentals of Digital Image and Video Processing.

Course Title	**:**	Medical Image Processing			
Course Code	**:**	CS624	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	The course aims to provide foundation, as well as a thorough explanation of the techniques involved in medical image processing. The students would be able to understand practical interpretations of all theoretical concepts.			

Course Details:

Module 1: Images as multidimensional signals, Analogue and Digital image representations, Medical images obtained with ionizing radiation: Images from x-rays (Computed Radiography, Mammography, Computed Tomography), Images from γ-rays (Positron Emission Tomography), Medical images obtained with non-ionizing radiation: Ultrasound imaging, Magnetic Resonance Imaging, Picture archiving and communication systems (PACS), problems with medical images. **[10H]**

Module 2: Pixels and Voxels, Gray Scale and Color Representation, Image File Formats (DICOM, Analyze 7.5, NIfTI, and Interfile), Image Quality and the Signal-to-Noise Ratio, Image Processing in Clinical Practice, Image Databases, intensity transformation function and dynamic range, improving visibility of low contrast images, noise reduction filters for medical images. **[10H]**

Module 3: Tissue and mass segmentation, ROI Definition and Centroids, evaluation of segmentation results, Interpolation and Volume Regularization, Translation and Rotation, Registration Paradigms, Merit Functions, Optimization Strategies, Camera Calibration, Registration to Physical Space, Rendering and Surface Models. **[10H]**

Module 4: CT Reconstruction, Image Guided Therapy, Content based medical image retrieval, Case studies: Development of CAD systems based on mammograms and MRI images, its performance evaluation, and some practical issues with the usage of these systems. **[10H]**

Text/Reference books:

1. W. Birkfellne, Applied Medical Image Processing: A Basic Course, CRC Press, 2011.
2. G. Dougherty, Digital Image Processing for Medical Applications, Cambridge University Press, 2010.
3. J. Jan, Medical Image Processing, Reconstruction and Restoration: Concepts and Methods, CRC Press, 2005.
4. I. Bankman, Handbook of medical Image processing and Analysis, Second Edition (Academic Press Series in Biomedical Engineering), Elsevier, 2000.
5. A. A. Farag, Biomedical Image Analysis: Statistical and Variational Methods, Cambridge University Press, 2014.

Course Title	**:**	Biometric Technologies and Applications			
Course Code	**:**	CS625	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	This course aims to provide a strong background in the field of biometrics. The students will be encouraged to develop a biometric system based on various modalities.			

Course Details:

Module 1: Introduction to Biometric System: Definition, Characteristics, Verification and identification, Biometric system components, Applications of common biometrics, Privacy and Ethical use of Biometrics. Fundamentals of Digital Image Processing: Image Fundamentals, Image Enhancement, Edge Detection. **[10H]**

Module 2: Some state of the art feature extraction, dimension reduction, and classification techniques (as required for discussion of topics in Module 3). **[10H]**

Module 3: Biometrics Technologies in visible and thermal domain: Fingerprint scan, Face recognition, Palmprint recognition, Iris recognition, Multimodal biometrics (apart from standard text, this module will include discussion on some recent research papers). **[10H]**

Module 4: Testing and Evaluation of Biometric systems, Statistical Measures of Biometrics, Performance matrices, ROC curves, Cost functions, Tradeoff of performance parameters, Biometric System Selection. System issues. **[10H]**

Text/Reference books:

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Third Edition, Pearson, 2012.
2. R. M. Bolle, J. H. Connell, S. Pankanti, N. K. Ratha, A. W. Senior, Guide to Biometrics, Springer International Edition, 2009.
3. A.K. Jain, P. Flynn, A. K. Ross, Handbook of Biometrics, Springer 2007.
4. Recent research papers will be provided by the instructor.

Course Title	**:**	Content Based Image Retrieval			
Course Code	**:**	CS626	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	The course is aimed at introducing the concept and techniques in content-based image retrieval as used in various vision based applications. After learning these techniques, the students will be able to understand implementation of existing image search engines. With the practical exposure, they will be able to develop their own CBIR systems for different applications.			

Course Details:

Module 1: Introduction: Digital Image Representation and Low Level Image Features, Basic Principles for Image Retrieval, Applications. Comparing Images: Comparing Features, Different Distance Functions, Performance Evaluation for Content-Based Image Retrieval. **[7H]**

Module 2: Human Visual Perception, Color models and features, Texture features including statistical and spectral features. **[10H]**

Module 3: Shape features, Object-Recognition and Classification of Images. **[10H]**

Module 4: Fusion methods, Multidimensional Indexing and Curse of Dimensionality. **[8H]**

Module 5: High Level Semantic Concepts: Image Semantics; Semantic gap; Current techniques in reducing the Semantic gap. Image Databases and other research issues; Study of a few existing systems. **[5H]**

Text/Reference books:

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Third Edition, Pearson, 2012.
2. M Sonka, V Hlavac, R Boyle, Image Processing, Analysis, and Machine Vision, Third Edition, Thomson Engineering, 2007.
3. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Ltd, 2011.
4. Also, relevant research papers will be provided by the instructor.

Course Title	:	Image Reconstruction			
Course Code	:	CS627	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	Course includes the theory behind the reconstruction of the medical images. Examples will range from CT, PET, SPECT and MRI.			

Course Details:

Module 1: One-dimensional signal processing, Fourier analysis, Line integrals and projections, Fourier slice theorem. **[10H]**

Module 2: Reconstruction algorithms for parallel projections, Reconstruction algorithms for fan beam projections, Rebinding, Conversion of fan beam projection to parallel beam projections. **[10H]**

Module 3: Reconstruction algorithms for Cone beam projections geometries, Circular scan geometry, Helical scan geometry, Reconstruction of long objects. **[10H]**

Module 4: Algebraic reconstruction algorithms: Additive, multiplicative, Use of priory information in reconstruction, Implementation issues, Optimization based reconstruction algorithms. **[10H]**

Text/Reference books:

1. G. T. Herman, Image Reconstruction from Projections, Springer-Verlag, 2009.
2. W. A. Kalender, Computed Tomography, Willey, 2015.
3. F. Natterer, Mathematics of Computed Tomography, Taylor & Francis, 2015.
4. A. Kak, Slany, Principles of Computed Tomography, Springer, 2013.

Course Title	:	Parallel Algorithms			
Course Code	:	CS631	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will learn design and development of parallel algorithms on different parallel architectures.			

Course Details:

Module 1: Parallel computational models; Performance metrics; Parallel programming; Complexity measure of parallel algorithms. **[10H]**

Module 2: Parallel Combinatorial algorithms; Parallel Searching algorithms. **[10H]**

Module 3: Parallel Sorting algorithms; Parallel Graph algorithms. **[10H]**

Module 4: Algorithms for linear algebraic equations; Issues of factorization; Implementation of classical iterative methods. **[10H]**

Text/Reference books:

1. Joseph Jaja, Introduction to Parallel Algorithms, Addison-Wesley Professional, 1992.
2. Sayed H Roosta, Parallel Processing and Parallel Algorithms, Springer, 2000.
3. Barry Wilkinson, Michael Allen, Parallel Programming: Techniques and Applications using Networked Workstations and Parallel Computers, Second Edition, Pearson education, 2006.
4. E. H. D’Hollander, G. R. Joubert, F. J. Peters, U Trottenberg, Parallel Computing: Fundamentals, Applications and New Directions, First Edition, Elsevier, 1998.

Course Title	**:**	Advanced Algorithms			
Course Code	**:**	CS632	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	The students will survey many of the techniques that apply broadly in the design of efficient algorithms. They will be able to apply this knowledge in a wide range of application domains and computational models.			

Course Details:

Module 1: Advanced data structures: self-adjustment, persistence and multidimensional trees. **[10H]**

Module 2: Geometric algorithms: Point location, Convex hulls and Voronoi diagrams, Arrangements applications using examples. **[10H]**

Module 3: Approximation algorithms: Use of Linear programming and primal dual, Local search heuristics, semidefinite programming, hyperplane rounding. **[10H]**

Module 4: String Algorithms: Rabin-Karp Fingerprinting Algorithm. Suffix Trees; Randomized algorithms: Use of probabilistic inequalities in analysis. **[10H]**

Text/Reference books:

1. T. H. Cormen, C. E. Leiserson, R L Rivest and C Stein, Introduction to Algorithms, Third Edition, MIT Press, 2009.
2. J .Kleinberg and E. Tardos, Algorithm Design, Addison Wesley, 2005.
3. Aho, J. E. Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms, AddisonWesley, 1974.
4. S. Sahni, Data Structures, Algorithms and Applications in C++, McGraw Hill, 2001.
5. M. T. Goodrich and R. Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, John Wiley & Sons, 2001.

Course Title	:	Approximation Algorithms			
Course Code	:	CS633	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The course is divided into three parts: (a) Combinatorial algorithms, (b) Linear programming based algorithms, and (c) Semidefinite programming based algorithms The students will learn several techniques to design and analyze many approximation algorithms for computationally hard problems.			

Course Details:

Module 1: Introduction and Methodology: P vs NP, NP Optimization problems, Approximation Ratio, Additive vs Multiplicative, Pros and Cons; Techniques: Greedy and combinatorial methods, Local search, Dynamic programming and approximation schemes**.[10H]**

Module 2: Linear programming rounding methods (randomized, primal-dual, dual-fitting, iterated rounding), Semi-definite program based rounding, Metric methods, Problems: Tour problems: Metric-TSP, Asymmetric TSP, TSP Path, Orienteering. **[10H]**

Module 3 Number Problems: knapsack, bin packing; Scheduling: multiprocessor scheduling, precedence constraints, generalized assignment; Connectivity and network design: Steiner trees, Steiner forests, Buy at bulk network design, Survivable Network Design; Covering problems: vertex cover, set cover and generalizations; Packing problems: maximum independent set, packing integer programs; Constraint satisfaction: max k-Sat; Clustering: k-center, k-median, facility location. **[10H]**

Module 4: Cut problems: max cut, multiway cut, k-cut, multicut, sparsest cut, bisection; Routing problems: congestion minimization, maximum disjoint paths, unsplittable flow, Hardness of approximation: simple proofs, approximation preserving reductions, some known results. **[10H]**

Text/Reference books:

1. Vijay Vazirani, Approximation Algorithms, Springer, 2001.
2. Dorit S. Hochbaum, Approximation Algorithms for NP-hard Problems, PWS Publishing, 1997.
3. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 2000.
4. Jon Kleinber and Eva Tardos, Algorithm Design, Addison-Wesley, 2006.

Course Title	:	Randomized Algorithms			
Course Code	:	CS634	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will learn to use randomization for designing simpler and more efficient algorithms via random sampling, random selection of witnesses, symmetry breaking, and Markov chains.			

Course Details:

Module 1: Tools and Techniques: Basic probability theory; randomized complexity theory; game-theoretic techniques; Markov, Chebyshev, and moment inequalities; limited independence; coupon collection and occupancy problems. **[10H]**

Module 2: Tail inequalities and Chernoff bounds; conditional expectation and martingales; Markov chains and random walks; stable distributions; probability amplification and derandomization. **[10H]**

Module 3: Applications: sorting and searching; data structures; combinatorial optimization and graph algorithms; geometric algorithms and linear programming. **[10H]**

Module 4: Approximation and counting problems; metric embedding; online and streaming algorithms; nearest neighbours, and clustering; number-theoretic algorithms. **[10H]**

Text/Reference books:

1. Motwani and Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
2. Mitzenmacher and Upfal, Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press, 1995.
3. William Feller, An introduction to Probability Theory and Its Applications, Volumes I and II, John Wiley, New York, 1968.
4. Patrick Billingsley, Probability and Measure, John Wiley and Sons, 1986.

Course Title	:	Computational Geometry			
Course Code	:	CS635	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will get detailed knowledge of the fundamental problems within computation geometry and general techniques for solving problems within computational geometry. They will be able to construct algorithms for simple geometrical problems.			

Course Details:

Module 1: Basic Geometric Concepts: points, lines, polygons; subdivisions; arrangements; polytopes; cell complexes. Geometric Searching: fractional cascading; segment tree; interval tree, range tree; priority search tree. **[10H]**

Module 2: Point Location: slab method; trapezoid method; chain method; bridged chain method. Plane-Sweep Algorithms: intersection of segments; intersection of rectangles; trapezoidation. **[10H]**

Module 3: Convex Hulls: 2-dimensional convex hull; dynamic convex hull; 3-dimensional convex hull. Proximity: closest pair; furthest pair; Voronoi diagrams; triangulations. **[10H]**

Module 4: Graph Drawing: planar drawings; straight-line drawings; orthogonal drawings; polyline drawings; upward drawings; hierarchical drawings; visibility representations. **[10H]**

Text/Reference books:

1. Mark de Berg, Mar van Kreveld, Mark Overmars, Otfried S hwarzkopf, Computational Geometry: Algorithms and Applications, Second Edition, Springer Verlag, 2000.
2. H. Edelsbrunner, Algorithms in Combinatorial Geometry, Springer Verlag, 1987.
3. H. Edelsbrunner, Geometry and Topology for Mesh Generation. Cambridge Univ. Press, 2001.
4. K. Mulmuley, Computational Geometry: An Introduction Through Randomized Algorithms, Prentice Hall, 1994.
5. F. Preparata and M. Shamos, Computational Geometry: An Introduction, Springer Verlag, 1985.
6. T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, Introduction to Algorithms Third Edition, MIT Press and McGraw Hill, 2009.

Course Title	**:**	Optimization Theory and Applications			
Course Code	**:**	CS636	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	This course will emphasis on and how to formulate the problems arising in management and engineering applications and solving these problems using various optimization techniques.			

Course Details:

Module 1: Formulation on LP, Geometry of LPP and Graphical solution to LPP, Simplex method, revised simplex method, Introduction to duality theorem, Primal dual Algorithm. **[10H]**

Module 2: Matching Algorithm, polyhedral combinatory, Matching polytopes on bipartite graphs and general graph. **[10H]**

Module 3: Flow duality and Algorithms, Minimum cuts, Ellipsoidal Algorithm, Separation oracles. **[10H]**

Module 4: NP-Completeness, Approximation Algorithms using optimization techniques **[10H]**

Text/Reference books:

1. Rajesh Kumar Arora, Optimization: Algorithms and Applications, CRC press, 2015.
2. D. Luenberger and Y. Ye, Linear and Nonlinear Programming, Fourth edition, Springer, 2016.
3. S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press New York, USA, 2004.
4. D. A. Pierre, Optimization theory with applications, Dover Publications, Inc. New York, USA, 1986.

Course Title	**:**	Mesh Free Computations			
Course Code	**:**	CS637	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	Course will enable the students to develop the algorithms which do not require arranging the data in structured manner.			

Course Details:

Module 1: Why Mesh Free, Definition of Mesh Free, Solution Procedure for Mesh Free methods Categories of Mesh Free methods.**[10H]**

Module 2: Mesh Free Shape Function Construction, Mesh Free methods based on global weak forms, Meshfree radial point interpolation methods, Element free Galerkin method, implementation issues. **[10H]**

Module 3: Mesh Free Collocation Methods, techniques for handling derivative boundary conditions, polynomial point collocation methods for 1D problems, Polynomial point collocation methods for 2D problems, radial point collocation methods for 2D problems. **[10H]**

Module 4: Meshfree collocation and local weak-form methods, formulation for 2D statics, Numerical Implementation, Implementation issues. **[10H]**

Text/Reference books:

1. G. R. Lui, and Y. T. Gu, An Introduction to Mesh Free Methods and Their Programming, Springer, 2005.
2. W. Chen, Z. J. Fu, and C. S. Chen, Recent Advances in Radial Basis Function Collocation Methods, Springer, 2014.
3. L Hua, S. S. Mulay, Meshless methods and their numerical properties, CRC Press, 2013.
4. V M A Leitao, C J S Alves, C A Duarte, Advances in Meshfree techniques, Springer, 2007.

Course Title	:	Principles of Programming Languages			
Course Code	:	CS641	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students shall be able to understand main principles of imperative, functional, object oriented and logic oriented programming languages. They will be able to compare and choose appropriate programming languages for certain classes of programming problems.			

Course Details:

Module 1: Introduction, Programming Languages, Syntax, Grammar, Ambiguity, Syntax and Semantics, Data Types (Primitive/Ordinal/Composite data types, Enumeration and sub-range types, Arrays and slices, Records, Unions, Pointers and pointer problems)**. [10H]**

Module 2: Expressions, Type conversion, Implicit/Explicit conversion, type systems, expression evaluation, Control Structures, Binding and Types of Binding, Lifetime, Referencing Environment (Visibility, Local/Nonlocal/Global variables) , Scope (Scope rules, Referencing operations, Static/Dynamic scoping). **[10H]**

Module 3: Subprograms, signature, Types of Parameters, Formal/Actual parameters, Subprogram overloading, Parameter Passing Mechanisms, Aliasing, Eager/Normal-order/Lazy evaluation) , Subprogram Implementation (Activation record, Static/Dynamic chain, Static chain method, Display method, Deap/Shallow access, Subprograms as parameters, Labels as parameters, Generic subprograms, Separate/Independent compilation). **[10H]**

Module 4: Logic Programming, Predicate calculus, Clausal form, Resolution, PROLOG programming language, Facts and rules, Backtracking, Lists, Limitations of PROLOG) , Functional Programming (Lambda notation, Referential transparency, Functional forms, LISP and SCHEME programming languages, S-expression, Define and Eval functions) **[10H]**

Text/Reference books:

1. Allen B. Tucker, Robert Noonan, Programming Languages: Principles and Paradigms, Tata McGraw Hill Education, 2006.
2. Bruce J. MacLennan, Principles of Programming Languages: Design, Evaluation, and Implementation, Third Edition, Oxford University Press, 1999.
3. T. W. Pratt, M. V. Zelkowitz, Programming Languages, Design and Implementation, Prentice Hall, Fourth Edition, 2001.
4. Robert Harper, Practical Foundations for Programming Languages, Second Edition, Cambridge University Press, 2016.

Course Title	:	Object Oriented Analysis and Design			
Course Code	:	CS642	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The student will learn analyzing and designing an application, system, or business by applying the object-oriented paradigm, as well as using visual modeling throughout the development life cycles to foster better stakeholder communication and product quality.			

Course Details:

Module 1: Introduction to Object-Orientation, Objects and Classes, Attributes, Methods, Object Relationships like Association, Aggregation and Composition, Inheritance, Polymorphism and Dynamic Binding Interfaces, Programming constructs for various OO concepts, Components of UML class diagrams, and Sequence diagrams. **[10H]**

Module 2: Requirement analysis, SRS, Use case modeling, Identification of domain objects and interactions modeling, domain modeling, UML Component diagram/package diagram, Subsystem design, goals, Architectural patterns, Component of UML Activity diagrams, and State chart, Object design (solution domain). **[10H]**

Module 3: Methodologies for object-oriented analysis and design (OOAD), Design patterns, Common design patterns. Creational, Structural and Behavioral patterns. **[10H]**

Module 4: Refactoring, Code smells, Reverse Engineering Design from Code, Design Evaluations. **[10H]**

Text/Reference books:

1. Bruegge, Bernd, and Allen H. Dutoit. Object-Oriented Software Engineering Using UML, Patterns and Java-(Required). Prentice Hall, 2004.
2. Blaha, Michael, and James Rumbaugh. Object-oriented modeling and design with UML. Upper Saddle River: Pearson Education, 2005.
3. Grady Booch, James Rumbaugh, Ivar Jacobson, Object-oriented modeling and design with UML, Second Edition, Pearson Education, 2008.
4. Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Conallen, Kelli A. Houston, Object-Oriented Analysis and Design with Applications, Third Edition, Pearson Education, 2007.

Course Title	**:**	Fuzzy Sets, Logic and Applications			
Course Code	**:**	CS651	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	Provide an understanding of the basic mathematical elements of the theory of fuzzy sets. Provide an emphasis on the differences and similarities between fuzzy sets and classical sets theories.			

Course Details:

Module 1: Review of classical set theory and related concepts, Fuzzy sets and related concepts; membership functions, operations, algebra, etc., Mapping fuzzy sets and extension principle. **[10H]**

Module 2: Fuzzy numbers, Fuzzy relations, Fuzzy logic and relationship to binary logic. **[10H]**

Module 3: Fuzzy propositions-classical propositions and classical inference, Fuzzy inference using conditional propositions – Fuzzy inference systems. **[10H]**

Module 4: Learning algorithms for intelligent systems design, Fuzzy arithmetic concepts, Applications in robotics, control, etc. **[10H]**

Text/Reference books:

1. George Klir, Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall, 1995.
2. Witold Pedrycz, Fuzzy Sets Engineering, CRC Press, 1995.
3. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill, 1995.
4. S. S. Farinwata, D. P. Filev, R. Langari, Fuzzy Control: Synthesis and Analysis, Wiley, 2000.

Course Title	:	Statistical Methods in Computer Science			
Course Code	:	CS652	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The module provides an introduction to statistics and probability for computer scientists. The aim is to provide the basic grounding needed for machine learning and algorithm performance analysis. It also covers the applications of probabilistic and statistical techniques to algorithms, speech/image processing, and robotics.			

Course Details:

Module 1: Introduction to the probabilistic and statistical techniques used in modern computer systems, basics of probability and statistical estimation. **[10H]**

Module 2: Graphical models, Mixture models and the EM algorithm, HMM, Kalman Filters, Bayesian Networks, and Markov Networks, Variable elimination, junction tree, belief propagation. **[10H]**

Module 3 Sampling-based inference, Probabilistic inference, statistical learning, learning Bayesian network, learning Markov models. **[10H]**

Module 4: Decision theory, Markov decision processes, applications of probabilistic and statistical techniques to algorithms, speech/image processing, robotics. **[10H]**

Text/Reference books:

1. D. Koller, N. Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009.
2. Mari, Jean-François and Schott, René, Probabilistic and Statistical Methods in Computer Science Springer, 2001.
3. Frederick Jelinek, Statistical Methods for Speech Recognition, MIT Press, 1998.
4. Schuyler W. Huck, Reading Statistics and, Research, Fourth Edition, Pearson Education Inc., 2004.

Course Title	:	Artificial Intelligence			
Course Code	:	CS653	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will understand the principles and development of artificial intelligence. They will also learn its many applications in different areas.			

Course Details:

Module 1: Overview: foundations, scope, problems, and approaches of AI, Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques. Problem-solving through Search: forward and backward, state-space, blind, heuristic, problem-reduction, A, A*, AO*, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications. **[10H]**

Module 2: Knowledge Representation and Reasoning: ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. Planning: planning as search, partial order planning, construction and use of planning graph. **[10H]**

Module 3: Representing and Reasoning with Uncertain Knowledge: probability, connection to logic, independence, Bayes rule, bayesian networks, probabilistic inference, sample applications, Decision-Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications. **[10H]**

Module 4: Machine Learning and Knowledge Acquisition: learning from memorization, examples, explanation, and exploration, learning nearest neighbour, naive Bayes, and decision tree classifiers, Q-learning for learning action policies, applications, Sample Applications of AI. **[10H]**

Text/Reference books:

1. N. J. Nilsson, Artificial Intelligence-A Modern Synthesis. Palo Alto: Morgan Kaufmann, 1998.
2. N. J. Nilsson, Principles of Artificial Intelligence. Palo Alto, CA: Tioga, 1981.
3. E. Rich, K. Knight, Artificial Intelligence, New York: McGraw Hill, 1991.
4. S.S.V Chandra, S. A. Hareendran, Artificial Intelligence and Machine Learning, PHI, 2014.

Course Title	:	Big data analytics			
Course Code	:	CS654	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will learn in-depth a wide range of fundamental algorithms and processing platforms used in big data management.			

Course Details:

Module 1: Introduction: Introduction: Big Data Challenges , Big Data Collection: Data Cleaning and Integration, Hosted Data Platforms and the Cloud. **[10H]**

Module 2: Big Data Systems: Characteristics of Big Data and Dimensions of Scalability, Multicore, Scalability, Security, User Interfaces for Data. **[10H]**

Module 3: Big Data Storage Modern Databases, Distributed Computing Platforms, NoSQL, NewSQL. **[10H]**

Module 4: Big Data Analytics: Getting Value out of Big Data, Machine Learning Tools, Fast Algorithms, Data Compression, Information Summarization. **[10H]**

Text/Reference books:

1. Kuan-Ching Li, Hai Jiang, Laurence T. Yang, Alfredo Cuzzocrea, Big Data: Algorithms, Analytics, and Applications, CRC Press, 2015.
2. EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, John Wiley & Sons, 2015.
3. DT Editorial Services, Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization, Dreamtech Press, 2016.
4. Arshdeep Bahga, Vijay Madisetti, Big Data Science & Analytics: A Hands-On Approach, VPT, 2016.

Course Title	:	Cloud Computing			
Course Code	:	CS655	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	This course is designed to introduce the concepts of cloud computing as a new computing paradigm. The students will explore different views of understanding the cloud computing such as theoretical, technical and commercial aspects.			

Course Details:

Module 1: Security Overview of Distributed Computing: Trends of computing, Introduction to distributed computing, Next big thing: cloud computing, Introduction to Cloud Computing: Properties & Characteristics, Service models, Deployment models, Public cloud, private cloud and hybrid clouds. **[10H]**

Module 2: Cloud Computing Models including Infrastructure/Platform/Software – as-a-service: Resource Virtualization. **[10H]**

Module 3: Cloud platform & Management, Web services, Security and Privacy issues in the Cloud. **[10H]**

Module 4: Cloud issues and challenges: Cloud OS, Cloud Architectures including Federated Clouds, Scalability, Performance, QoS. **[10H]**

Text/Reference books:

1. Kai Hwang, Jack Dongarra, Geoffrey C. Fox, Distributed and Cloud Computing, First Edition, Morgan Kaufmann, 2011.
2. Ray J Rafaels, Cloud Computing: From Beginning to End, Create Space Independent Publishing Platform, 2015.
3. Thomas Erl, Zaigham Mahmood, Ricardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 2013.
4. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, Mastering Cloud Computing: Foundations and Applications Programming, Morgan Kaufmann, 2013.

Course Title	**:**	Basic of Bioinformatics			
Course Code	**:**	CS656	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	The basic objective is to give students an introduction to the basic practical techniques of bioinformatics. Emphasis will be given to the application of bioinformatics and biological databases to problem solving in real research problems.			

Course Details:

Module 1: Introduction to bioinformatics and data generation: Bioinformatics and its relation with molecular biology, examples of related tools, databases, software and applications. Data generation: Generation of large scale molecular biology data (through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). **[10H]**

Module 2: Biological Database and its Types: Introduction to data types and source, population and sample, classification and presentation of data, quality of data, private and public data sources, Biological Databases, Nucleic acid databases, Protein databases, Specialized Genome and Structure databases. **[10H]**

Module 3: Data Storage, Retrieval and Interoperability: Flat files, relational, object oriented databases and controlled vocabularies, File Formats, Introduction to Metadata and search, challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts. General Introduction to XML, UMLS, CORBA, PYTHON and OMG/LIFESCIENCE. **[10H]**

Module 4: Sequence Alignments and Visualization: Sequences, alignments and dynamic programming, local and global alignment, pairwise alignment, and multiple sequence alignment. Methods for presenting large quantities of biological data: sequence viewers, 3D structure viewers, and Anatomical visualization. Gene Expression and Representation of patterns and relationship: Gene expression in prokaryotes and eukaryotes, transcription factors binding sites, Introduction to Regular Expression, Hierarchies, and Graphical models, Genetic variability and connections to clinical data. **[10H]**

Text/Reference books:

1. Arthur M. Lesk, Introduction to Bioinformatics, Third Edition, Oxford University Press Inc., 2008.
2. Cynthia Gibas, Per Jambeck, Developing Bioinformatics Computer Skills: An Introduction to Software Tools for Biological Applications, O'Reilly Media, 2001.
3. David W. Mount, Bioinformatics: Sequence and Genome Analysis, Second Edition, CHS Press, 2001.
4. Jin Xiong, Essential Bioinformatics, Cambridge University Press, 2006.

Course Title	:	Quantitative Methods in Software Engineering			
Course Code	:	CS671	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The student should be able to understand the basic ingredients of experimentation and empirical investigations in software engineering. After learning this course, the student should be able to design an experiment, perform empirical study and should be able to validate the findings of the empirical study.			

Course Details:

Module 1: Assessment in software engineering, Software measurement and metrics, Research method in SE - Controlled experiment, Case studies, Surveys. **[10H]**

Module 2: Controlled Experiments, Design of experiments, Simulation methods, Examples and case studies for controlled experimentations, Data collection and analysis, Validity and interpretation. **[12H]**

Module 3: Case studies and surveys, Design and execution, Data collection, Data analysis, Statistical data analysis, Validity and interpretation. **[10H]**

Module 4: Planning, Designing, Conducting empirical studies, Replication, Documentation, Review, Examples. **[8H]**

Text/Reference books:

1. Natalia Juristo and Ana M. Moreno, Basics of Software Engineering Experimentation, Kluwer, 2001.
2. Forest Shull, Janice Singer, and Dag I.K. Sjøberg, Guide to Advanced Empirical Software Engineering, Springer, 2008.
3. Ruchika Malhotra, Empirical Research in Software Engineering: Concepts, Analysis, and Applications, Chapman and Hall/CRC, 2015.
4. C. Wohlin, P. Runeson, M. Höst, M.C. Ohlsson,, B. Regnell, and A. Wesslén, Experimentation in Software Engineering, Springer, 2012.

Course Title	:	Software Testing and Quality Assurance			
Course Code	:	CS672	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The objective of the course is to introduce the basic software testing techniques and trends followed in the software industry. After learning this course the student should be able to perform black box and white box testing of small software systems. Further, he should be able to gain the experience of standard open source tools used in software testing.			

Course Details:

Module 1: Introduction to software quality, quality attributes, quality assurance. Software testing, testing levels, unit testing, unit testing frameworks like JUnit, integration testing, system testing, user acceptance testing, alpha and beta testing. **[10H]**

Module 2: Testing techniques, black box techniques-equivalence partitioning, boundary value analysis, White box techniques-structural testing, control flow based - block, branch, predicate, MCDC, path testing, data flow based-p-use, d-use, all-use, and others, mutation testing, coverage criteria and code coverage, examples and case studies. **[10H]**

Module 3: Code reviews and inspections, Static code analysis, SCA tools (Findbugs, and others). Other specialized testing-performance testing, load testing, security testing, GUI testing. **[10H]**

Module 4: Regression testing, comparing testing techniques, evaluations. Testing process, testing artifacts, defect classification, other dynamic analysis. **[10H]**

Text/Reference books:

1. Paul C. Jorgensen, Software Testing: A Craftsman's Approach, Third Edition, Auerbach Publication, 2008.
2. Cem Kaner, Jack Falk, Testing Computer Software, Second Edition, Wiley, 1999.
3. Glenford J. Myers, The Art of Software Testing, Second Edition, John Wiley & Sons, 2004.
4. John D. McGregor, David A. Sykes, A Practical Guide to Testing Object-Oriented Software, First Edition, Addison-Wesley Professional, 2001.

Course Title	:	Human Computer Interaction			
Course Code	:	CS673	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The course introduces the elements of human computer interaction. After learning the course the student should be able to design interfaces and systems with due consideration to a user's perspective. He/she should be able to evaluate a system or a model with respect to the HCI standards.			

Course Details:

Module 1: Introduction to Human-Computer Interaction: design focus, human memory, thinking, reasoning and problem solving, Psychology and the design of interactive systems, human factors.
Task-centered system design: task-centered process, development of task examples, evaluation of designs through a task-centered walk-through. **[8H]**

Module 2: User-centered design and prototyping: assumptions, participatory design, methods for involving the user, prototyping, low fidelity prototypes, medium fidelity. **[10H]**

Module 3: Methods for evaluation of interfaces with users: goals of evaluation, approaches, ethics, introspection, extracting the conceptual model, direct observation, constructive interaction, interviews and questionnaires, continuous evaluation via user feedback and field studies, choosing an evaluation method. Beyond screen design: characteristics of good representations, information visualization, Tufte's guidelines, visual variables, metaphors, direct manipulation. **[12H]**

Module 4: Graphical screen design: graphical design concepts, components of visible language, graphical design by grids. Design principles and usability heuristics: design principles, principles to support usability, golden rules and heuristics, HCI patterns, HCI design standards: process-oriented standards, product-oriented standards, strengths and limitations of HCI Standards. **[10H]**

Text/Reference books:

1. Alan Dix, Janet Finlay, Gregory D. Abowd, and Russell Beale., Human-Computer Interaction, Third Edition, Prentice Hall, 2004.
2. Yvonne Rogers, Helen Sharp and Jenny Preece, Interaction Design: Beyond Human Computer Interaction, Third Edition, Wiley, 2011.
3. Serengul Smith-Atakan, Human-Computer Interaction: Basics and Practice, Ceneage Learning India Pvt Ltd, First Edition, 2010.
4. Julie A. Jacko, Human Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition, CRC Press, 2012.

Course Title	**:**	Distributed Systems			
Course Code	**:**	CS674	**Course Type**	**:**	Elective
Contact Hours	**:**	L- 3 T- 0 P- 0	**Credit**	**:**	4
Program/Semester	**:**	UG/PG/ Semester-I,II			
Pre-requisites	**:**	None			
Evaluation Scheme	**:**	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	**:**	The aim of this course to learn different distributed architectures and how to develop efficient processes for these architectures			

Course Details:

Module 1: Distributed systems and their types, System architectures and self-management in distributed systems, Processes, Communication. **[10H]**

Module 2: Flat, structured and attribute based naming, Synchronization, Consistency models and protocols, Replica management. **[10H]**

Module 3: Fault Tolerance, Reliable schemes, Error models and recovery, Security management. **[10H]**

Module 4: Case studies: Distributed Object-based Systems, Distributed File Systems, Distributed Web-based Systems, and Distributed Coordination-based Systems. **[10H]**

Text/Reference books:

1. A. S. Tanenbaum, Distributed Systems: Principles and Paradigms, PHI, 2007.
2. G. Coulouris, J. Dollimore, T. Kindberg, Distributed Systems, Pearson, 2009.
3. H. E. Bal, Programming Distributed Systems, Silicon Press, 1990.
4. Sukumar Ghosh, Distributed Systems: An Algorithmic Approach, CRC Press, 2015.

Course Title	:	Coding Theory			
Course Code	:	CS681	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will be introduced fundamental concepts, theoretical aspects, algorithmic questions and applications of coding theory. They will also learn the basics of algebraic coding theory, convolutional codes, turbo codes and space-time codes.			

Course Details:

Module 1: Review of basic concepts: probability including Bayesian analysis, Introduction to entropy and information content, Basics of coding theory: Finite fields, linear codes, generator and parity check matrices. **[10H]**

Module 2: General theory of data compressions: Overview of specific data compression techniques, Channel capacity theory, Shannon's Noisy Channel Coding Theorem. **[10H]**

Module 3: Some Interesting Codes: Repetition Codes, Hamming Codes, Hadamard Codes Cyclic Codes, BCH Codes, Reed-Solomon Codes, The Golay Codes. **[10H]**

Module 4: Bounds on Codes: Krawtchouk Polynomials and the Linear Programming Bound, Asymptotic Bounds, Evaluation of different coding techniques in specific situations **[10H]**

Text/Reference books:

1. J. H. van Lint, Introduction to Coding Theory, Third Edition. Graduate Texts in Mathematics, Springer Verlag, Berlin, 1999.
2. W. C. Huffman and V. Pless, Fundamentals of error-correcting codes. Cambridge University Press, Cambridge, 2003.
3. D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger , J. R. Wall, Coding Theory and Cryptography: The Essentials, Second Edition, New York: Marcel Dekker, 1991.
4. M. Sudan, MIT Lecture Notes on Coding Theory, http://people.csail.mit.edu/madhu/FT01/.

Course Title	:	Cyber security			
Course Code	:	CS682	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	This course covers the basics of the current leading cybersecurity topics and Network Security providing an opportunity to the listeners to understand the security concerns, vulnerabilities, attacks and to plan and implement the desired e-Security solutions.			

Course Details:

Module 1: Security Concepts and Mechanisms: Overview of Networking Concepts, Information Security Concepts, Security Threats and Vulnerabilities, Cryptography **[10H]**

Module 2: Security Management: Security Management Practices, Security Laws and Standards. [**10H]**

Module 3: Information and Network Security: Access Control and Intrusion Detection, Server Management and Firewalls, Security for VPN and Next Generation Technologies. **[10H]**

Module 4: System and Application Security: Security Architectures and Models, System Security, OS Security. **[10H]**

Text/Reference books:

1. M. Shema, Anti-Hacker Tool Kit, Fourth Edition, McGraw Hill, 2014.
2. N. Godbole and S. Belpure, Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley India Pvt Ltd, 2011.
3. Dieter Gollmann, Computer Security, Third Edition, Wiley, 2011.
4. Ross Anderson, Security Engineering: A Guide to Building Dependable Distributed Systems, Second Edition, Wiley, 2008.

Course Title	:	Visual Cryptography and Data Hiding			
Course Code	:	CS683	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The student should be able to understand the concept and importance of Visual Cryptography (VC) and data hiding in images. The student will have an exposure to some of the recent trends followed in VC and data hiding in images. He/she would be able to implement some of the fundamental techniques of VSS and data hiding.			

Course Details:

Module 1: Introduction, Visual Secret Sharing (VSS), definition and construction, Naor and Shamir's (k,n) VSS, Proof of correctness, Contrast and pixel expansion, Contrast bounds. **[10H]**

Module 2: Visual Cryptography for multiple secrets, Two secret sharing, Multiple secret sharing, XOR based visual cryptography, Random grids, Visual cryptograms of random grids. [**10H]**

Module 3: Colour image VSS, Color superposition, Formal models for color visual cryptography, Schemes for the sc model, Schemes for the nd model, Schemes for the general model, Chaotic map based VSS techniques. **[10H]**

Module 4: Data hiding schemes, Characteristics of data hiding schemes: Security, Payload, Imperceptibility, Reversible data hiding schemes, Random grid based methods, Applications in digital image watermarking. **[10H]**

Text/Reference books:

1. Stelvio Clemato and Ching-Yung Yang, Visual Cryptography and Secret Image Sharing, CRC Press, 2012.
2. Feng Liu and Wei Qi Yan, Visual Cryptography for Image Processing and Security: Theory, Methods, and Applications, Springer, 2015.
3. Husrev T. Sencar, Mahalingam Ramkumar, and Ali N. Akansu, Data Hiding Fundamentals and Applications: Content Security in Digital Multimedia, Elsevier Publication, 2004.
4. Pierre Moulin and Alan Bovik, Data Hiding (Synthesis Lectures on Image, Video, and Multimedia Processing), Morgan and Claypool Publishers, 2007.

Course Title	:	Cryptography and Network Security			
Course Code	:	CS684	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	The students will learn the fundamental concepts, theory and techniques of Cryptography and its application to Network Security.			

Course Details:

Module 1: Conventional Cryptography: Classical encryption techniques, Finite fields, Perfect Secrecy DES, AES and other symmetric cryptography. **[10H]**

Module 2: Number Theory, public key cryptography: RSA, ElGamal, and Elliptic Curve Cryptography, Key management. **[10H]**

Module 3: Authentication: Message authentications and hash functions, hash algorithms, Digital Signatures and Authentication Protocols. **[10H]**

Module 4: Network and System Security: Vulnerability, Monitoring/Sniffing, Spoofing, Firewalls, Intrusion Detection, PGP, Kerberos, IPSec, SSL. **[10H]**

Text/Reference books:

1. C. Kaufman, R. Perlman, M. Speciner, Network Security, Second Edition, Pearson Education, 2006.
2. B. A. Forouzan, Cryptograpgy and Network Security, Tata McGraw Hill, 2007.
3. A. D. Rubin, White Hat Security Arsenal: Tackling the Threats, Addison-Wesley, 2001.
4. P. Garrett, Making and Breaking Codes- An Introduction to Cryptology, Prentice-Hall, 2001.
5. N. Smart, Cryptography: An Introduction, McGraw-Hill, 2002.
6. B. Schneier, Applied Cryptography, Second Edition, John Wiley & Sons Inc., 1996.
7. A. Menezes, P. van Oorschot, S. Vanstone, Handbook of Applied Cryptography, CRC Press, 1997.
8. W. Stallings, Cryptography and Network Security: Principles and Practice, Fifth Edition, Prentice Hall, 2011.
9. D.R. Stinson, Cryptography: Theory and Practice, Third Edition, CRC Press, 2006.

Course Title	:	Advanced Computer Architecture			
Course Code	:	CS691	**Course Type**	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	**Credit**	:	4
Program/Semester	:	UG/PG/ Semester-I,II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End term (40%), Project (20%)			
Learning Objective	:	Students would be able to learn the advanced concepts of computer Architecture, e.g., Pipelining, Advanced Arithmetic Unit, Protection Mechanism and High Performance Computing.			

Course Details:

Module 1: Microprocessor Advances, Number of transistors, Chip size, Power dissipation, Simplified Computer structure, Clock synchronous design, Instruction fetch, decode, and execute. Pipeline Execution, Eliminating structural hazard, Resource scheduling, Data hazard, Pipeline control, Branch instruction execution, Pipeline processor performance, Number of pipeline stages. **[10H]**

Module 2: Parallel prefix Adder, Kogge-Stone adder, Han-Carlson adder, Multiplier, Binary multiplier, Booth's algorithm, Radix-4 modified Booth algorithm, Wallace tree, Pipelined Multiplier, Division, Restoring division, Non restoring division, SRT division, Floating point numbers, IEEE754, Floating point adder, Floating point multiplier, Iterative floating point division, Newton-Raphson method, Goldschmidt method. **[10H]**

Module 3: Memory management and Protection Mechanism: Segment and page based memory management, Page table, Memory protection, Translation look-aside buffer (TLB), Multi-level page table, Large page, Virtually indexed-physically tagged cache, TLB for multi-processing.
Superscalar execution, Out-of-Order execution, Anti-dependency hazard, Register renaming, Reorder buffer, Pipelined non-blocking cache, Load store unit, Commit mechanism, Control hazard reduction, Branch prediction, Branch target buffer, Return stack. **[10H]**

Module 4: Shared Memory system, Cache coherency, MSI protocol, snoop invalidate and snoop writeback, MESI, MOSI, MOESI, MESIF protocol, False sharing, Multiprocessor memory access, Mutual exclusion, Atomic memory access, Shared memory system, Distributed memory system, Static and dynamic networks, Static network topologies, Bisection band width, network diameter, dynamic network topology, Fat tree, Shared memory multiprocessor OS. **[10H]**

Text/Reference books:

1. D. A. Patterson, J. L. Hennessy, Computer Organization and Design, Fifth Edition, The Hardware/ Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design), 2007.
2. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, Fourteenth Reprint, TMH, 2007.
3. Kai Hwang, N. Jotwani. Advanced Computer Architecture, 3e. McGraw-Hill Education, 2011.
4. Michael J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Jones & Bartlett Learning, 1995.

Electives in Modular Form Courses Description

Course Title	:	Advanced Topics in Computer Architecture			
Course Code	:	EM601a	**Course Type**	:	EMF
Contact Hours	:	L- 2 T- 0 P- 0	**Credit**	:	2
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	Students would be able to learn the advanced concepts of Computer Architecture, e.g., Pipelining, Advanced Arithmetic Unit, Protection Mechanism and High Performance Computing.			

Course Details:

Module 1: Pipeline execution and Hazard avoidance: Simplified Computer structure, Clock synchronous design, Instruction fetch, decode, Operand read, ALU operation, LSU operation, Result write back; Pipeline Execution, Eliminating structural hazard, Resource scheduling, Data hazard, Pipeline control, Branch instruction execution, Pipeline processor performance, Number of pipeline stages. Advanced Arithmetic Units: Parallel prefix Adder, Kogge-Stone adder, Han-Carlson adder; Multiplier, Wallace tree, Pipelined Multiplier; Floating point numbers, IEEE754, Floating point adder, Floating point multiplier, Iterative floating point division, Newton-Raphson method, Goldschmidt method. **[10H**]

Module 2: Architectures for Higher Performance: Superscalar execution, Out-of-Order execution, Anti-dependency hazard, Register renaming, Reorder buffer, Pipelined non-blocking cache, Load store unit, Memory dis-ambiguation, Commit mechanism, Control hazard reduction, Branch prediction, Single level 2bit predictor, Tow level predictor, Branch target buffer, Return stack. Multi-processor System: Shared Memory system, Cache coherency, MSI protocol, snoop invalidate, snoop writeback, MESI, MOSI, MOESI, MESIF protocol, False sharing; Multiprocessor memory access, Mutual exclusion, Atomic memory access; Shared memory system, Distributed memory system; Static and dynamic networks, Static network topologies, Bisection band width, network diameter, dynamic network topology, Fat tree; Shared memory multiprocessor OS, Shared memory system programming, fork exec, pthread, OpenMP, Multiprocessing with distributed memory system, Programming with MPI Library. **[10H]**

Text/ Reference books:

1. D. A. Patterson, and J. L. Hennessy, Computer Organization and Design, Fifth Edition: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design), Fourth Edition, Morgan Kaufmann, 2008.
2. K. Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, First Edition, Tata McGraw-Hill Education, 1993.
3. K. Hwang, and N. Jotwani, Advanced Computer Architecture, Third Edition, McGraw-Hill, 2011.
4. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Jones & Bartlett Learning, 1995.

Course Title	**:**	Parallel Processing			
Course Code	**:**	EM601d	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	Students will get familiarized with different parallel architectures and efficient ways to utilize them.			

Course Details:

Module 1: What is parallel processing? Why needed? History of Super computers and Trends. Classification of Parallel Architecture (Form CPU to system), Memory architecture (Shared, distributed). Computational Models. Parallel Algorithms: Serial vs. Parallel Algorithms. Hardware Realization and Examples of special –purpose processors. Parallel Programming Languages: Relations between parallel languages and architecture. Parallel language for shared-memory architecture – open MP. Parallel languages for Distributed-memory architecture - Message passing Interface. Application Areas for the large scale scientific computation/simulation. Grid computing and cloud**. [10H]**

Text/ Reference books:

1. P. Pacheco, Introduction to Parallel programming, First Edition, Morgan Kaufmann, 2011.
2. P. Pacheco, Parallel programming with MPI, Morgan Kaufmann, 1996.
3. R. K. Ghosh, P. Gupta, and R. Moona, Foundation of Parallel Processing, Narosa Publication, 1995.
4. E. H. D. Hollander, G. R. Joubert, F. J. Peters, and U. Trottenberg, Parallel Computing: Fundamentals, Applications and new directions, Elsevier, 1998.

Course Title	**:**	Dependable Computing			
Course Code	**:**	EM601h	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	Understanding basic concepts, methods and techniques for realizing dependable information systems in the presence of human mistakes and physical malfunctions.			

Course Details:

Module 1: Introduction of Dependable Computing. Error Detection: Error models, Evaluation Metrics, Redundancy techniques, and Error-detecting Codes. Fault Tolerance and Recovery, Issues in Distributed Systems: Clock Synchronization, Mutual Exclusion, Concurrency control, Multiple copy update, Error recovery. Dependability Evaluation: Dependability over system's lifetime from users' point of view, Evaluation matrices, and Fault modelling. **[10H]**

Text/ Reference books:

1. J. C. Avizienis, B. Laprie, Randell, C. Landwehr: Basic Concepts and Taxonomy of Dependable and Secure Computing, IEEE Trans. on Dependable and Secure Computing, Vol.1, no.1, Jan.-March 2004.
2. D. P. Siewiorek, R. Swartz: Reliable Computer Systems, Design and Evaluation, Third Edition, A K Peters, Ltd., 1998.
3. K. Kanoun, L.Spainhower: Dependability Benchmarking for Computer Systems, IEEE Computer Society / John Wiley & Sons, 2008, 1995.

Course Title	**:**	Artificial Intelligence and its Applications			
Course Code	**:**	EM602d	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	In this course, the brief history of AI is lectured first. Then the main function of AI is explained, which are "knowledge representation", "search" and "decision". After that several hot topics of state-of-the-art AI will be discussed.			

Course Details:

Module 1: Brief history of AI, Examples of AI systems and basic components in AI. Knowledge representation, Symbol based and signal based knowledge representations, Search of planning, Tree search, Beam search, Recognition and optimization, machine learning and AI, Applications of AI : speech and dialogue recognition, image recognition, natural language processing. **[10H]**

Text/ Reference books:

1. N. J. Nilsson, Artificial Intelligence - A New Synthesis, Morgan Kaufmann, 1998.
2. N. J. Nilsson, Principles of Artificial Intelligence, Morgan Kaufmann, 1980.
3. P. H. Winston, Artificial Intelligence, Addison-Wesley Longman Publishing, 1992.
4. S. S. V. Chandra, Artificial Intelligence and Machine Learning, PHI Learning, 2014.

Course Title	**:**	Bayesian Classifiers			
Course Code	**:**	EM602e	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 2 T- 0 P- 0	**Credit**	**:**	2
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	The course will provide students sufficient knowledge about the Bayesian classifier. This course will cover the other classifiers from the Bayesian classifier.			

Course Details:

Module 1: Bayes Decision Theory, Minimum Error and Minimum Risk Classifiers, Discriminant Function and Decision Boundary, Normal Density, Discriminant Function for Discrete, Features, Parameter Estimation**. [20H]**

Text/ Reference books:

1. R. O. Duda, P. E. Hart, and D. G. Strok, Pattern Classification, Second Edition, Wiley Inderscience, 2000.
2. C. M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
3. T. M. Mitchell, Machine Learning, Mcgraw Hill Education, 1997.
4. S. Theodoridis and K. Koutroumbas, Pattern Recognition, Fifth Edition, Academic Press, 2008.

Course Title	**:**	Introduction to Coding Theory			
Course Code	**:**	EM605f	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	This course introduces the theory of error-correcting codes with a focus on the asymptotic, algebraic, and algorithmic aspects.			

Course Details:

Module 1: Basic concepts of codes and finite fields, linear code, Bounds on the size of codes, cyclic codes, and basic of BCH codes and Reed Solo man Codes. **[10H]**

Text/ Reference books:

1. J. H. V. Lint, Introduction to coding theory, Third Edition, Springer-Verlag New York, 1998.
2. W. C. Huffman and V. Pless, Fundamentals of error-correcting codes. Cambridge University Press, 2003.
3. D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger,and J. R. Wall, Coding theory and cryptography: The essentials, Second Edition, CRC press, 2000.
4. M. Sudan's MIT lecture notes on coding theory which are available online http://people.csail.mit.edu/madhu/FT01/

Course Title	**:**	Network Flow Optimization			
Course Code	**:**	EM605h	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 2 T- 0 P- 0	**Credit**	**:**	2
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Test / Assignments/Project (20%), Mid-term (30%), End term (50%) (Tentative)			
Learning Objective	**:**	Basic objective of the course is to provide a brief introduction to network flow optimization problems, their applications and different algorithmic solutions.			

Course Details:

Module 1: : Introduction and applications of network flow optimization problems, Maximum flow problem, Basic ideas, Generic augmenting path algorithm, Labeling algorithm and the Max-Flow Min-Cut Theorem, Flows with lower bounds. Efficient Max flow algorithms, Polynomial time algorithms-Capacity scaling**. [10H]**

Module 2: Minimum cost flows, Optimality conditions, Minimum cost flow duality, successive shortest path algorithm, Primal-dual algorithm, Minimum spanning trees, A brief introduction to sensitivity analysis, Lagrange relaxation and network optimization; Generalized flows; Multi-commodity flows; Recent Trends**. [10H]**

Text/ Reference books:

1. R. K. Ahuja, T. L. Magnant, and J. B. Orlin, Network Flows: Theory, Algorithms, and Applications, Prentice Hall, 1993.
2. L. Ambrosio, A. Bressan, D. Helbing, A. Klar, and E. Zuazua, Modelling and Optimization of Flows on Networks, Springer, 2013.
3. T. Michael, Flow Networks, First Edition, Elsevier Publication, 2013.
4. H. A. Eiselt and C. L. Sandblom, Integer Programming and Network Models, Springer, 2000.
5. MIT Open Courseware.

<table>
<tr><td>Course Title</td><td>:</td><td colspan="4">External Memory Algorithms</td></tr>
<tr><td>Course Code</td><td>:</td><td>EM605i</td><td>Course Type</td><td>:</td><td>EMF</td></tr>
<tr><td>Contact Hours</td><td>:</td><td>L- 2 T- 0 P- 0</td><td>Credit</td><td>:</td><td>2</td></tr>
<tr><td>Program/Semester</td><td>:</td><td colspan="4">UG/PG, I/ II</td></tr>
<tr><td>Pre-requisites</td><td>:</td><td colspan="4">None</td></tr>
<tr><td>Evaluation Scheme</td><td>:</td><td colspan="4">Mid-Term (30%), End Term (70%) (Tentative)</td></tr>
<tr><td>Learning Objective</td><td>:</td><td colspan="4">We will study the design and analysis of efficient external memory algorithms and data structures.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Course Details:</td></tr>
<tr><td colspan="6">Module 1: Hierarchical memory levels performance characteristics, parallel disk model, Cache oblivious algorithms, Fundamental I/O operations, design and analysis of efficient external memory algorithms for some representative problems: Sorting, permutation, searching Depth first search, breadth first search, Minimum spanning forest, connected components, single source shortest path. [10H]

Module 2: External Memory Data Structures: B Tree, B+ Tree and Buffer Tree. Large Matrix Computations: Matrix multiplications, LU, Cholesky and QR decomposition, System of linear equations, Eigenvalue Problems. [10H]</td></tr>
<tr><td colspan="6">Text/ Reference books:

1. J. S. Vitter, External Memory Algorithms and Data Structures: Dealing with massive data. ACM Computing Surveys, 33 (2), June 2001, 209-271.
2. Course Material on External Memory Algorithms and Data Structures http://www.cs.au.dk/~gerth/emf03/.</td></tr>
</table>

Course Title	**:**	Design of Extensible Application in Java			
Course Code	**:**	EM607a	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	In this course, students will learn advance topics of JAVA.			

Course Details:

Module 1: Introduction to modularity and Extensible application. Design of simple car Vendor application for Airport. Introduction to Java Script Loader and Reflection. Introduction to Eclipse Plugin Development. Writing Extensible Plugins. Re-Writing the Car Vendor Application using Plugin Architecture. **[10H]**

Text/ Reference books:

1. B. Bates, K. Sierra, and B. Basham, Head First Servlets & JSP, Second Edition, O'Reilly Media, 2011.
2. D. C. Ashmore, The Java EE Architect's Handbook, Second Edition: How to be a successful application architect for Java EE applications, Second Edition, DVT Press, 2014.
3. H. Schildt, Java: The Complete Reference, Ninth Edition, McGraw Hill, 2014.
4. C. Horstmann and G. Cornell, Core java (TM) 2, Volume II- Advance Features, Seventh Edition, Prentice Hall PTR Upper Saddle River, NJ, USA, 2004.

Course Title	**:**	Modelling and Simulation			
Course Code	**:**	EM608a	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	This course will cover the representation and simulation of physical systems using a range of mathematical formulations.			

Course Details:

Module 1: Nature of computer modeling & simulation – continues versus discrete approach. Use of simulation and its appropriateness, limitations, areas of application and recent applications. Concepts, systems approach to problem – solving, characteristics of a systems; state of a system, systems boundary and environment, different views of systems. Types of models, modeling methodology, models from various domains. Poisson arrival patterns, Exponential distribution, Service times, Normal Distribution. Queuing Disciplines, simulation of single and two server queue, Application of queuing theory in computer system. **[10H]**

Text/ Reference books:

1. B. P. Zeigler, T. Kim, and H. Praehofer, Theory of Modeling and Simulation, Second Edition, Academic Press, 2000.
2. J. Banks, Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice, John Wiley & Sons, New York, 2007.
3. A. J. Sokolowski and C. M. Banks, Principles of Modeling and Simulation: A Multidisciplinary Approach, John Wiley & Sons, Hoboken, New Jersey, 2009.
4. A.M. Law, and W.D. Kelton, Simulation Modeling and Analysis, Third Edition, McGraw Hill, New York, NY, 2000.

Course Title	:	Graphical Models			
Course Code	:	EM608b	**Course Type**	:	EMF
Contact Hours	:	L- 2 T- 0 P- 0	**Credit**	:	2
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	The aim of this course is to make it possible to understand a wide variety of network-based approaches to computation, and in particular to understand many neural network algorithms and architectures as instances of a broader probabilistic methodology.			

Course Details:

Module 1: Introduction and Foundations of probability, Structured Probabilistic Models, Probability Theory, Graphs, Bayesian Network Representation Exploiting independence Properties, Bayesian Networks, Independencies in Graphs, From Distributions to Graphs. **[10H]**

Module 2: Undirected graphical Models**,** The Misconception Example, Parameterization, Markov Network Independencies, Bayesian Networks and Markov Networks, Partially Directed Models. **[10H]**

Text/ Reference books:

1. D. Koller, and N. Fridman, Probabilistic Graphical Models Principles and Techniques, MIT press, 2009.
2. M. I. Jordan and T. J. Sejnowski, Graphical Models: Foundations of Neural Computation, MIT Press Cambridge, MA, USA, 2001.
3. S. L. Lauritzen, Graphical Models, Oxford University Press, 1996.
4. A. Mittal, Bayesian Network Technologies: Applications and Graphical Models, IGI Publishing Hershey, PA, USA, 2007.

Course Title	:	Public Key Cryptography			
Course Code	:	EM609b	**Course Type**	:	EMF
Contact Hours	:	L- 1 T- 0 P- 0	**Credit**	:	1
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	This course covers the fundamental principle of public key cryptosystems and their applications. In this course application of finite fields in public key cryptography are shown.			
Course Details:					
Module 1: Principles of public-key cryptosystems, RSA algorithm, Diffie-Hellman key exchange, ElGamal cryptosystem and digital signature. **[10H]**					

Text/ Reference books:

1. W. Stallings, Cryptography and Network Security: Principles and Practice, Fifth Edition, Prentice Hall, 2011.
2. C. Kaufman, R. Perlman, and M. Speciner, Network Security, Second Edition, Pearson Education, 2006.
3. B. A. Forouzan, Cryptograpgy and Network Security, Tata McGraw Hill, 2007.
4. A. D. Rubin, White Hat Security Arsenal: Tackling the Threats, Addison-Wesley, 2001.

Course Title	**:**	Speech and Music Signal Processing			
Course Code	**:**	EM609c	**Course Type**	**:**	EMF
Contact Hours	**:**	L- 1 T- 0 P- 0	**Credit**	**:**	1
Program/Semester	**:**	UG/PG, I/ II			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	**:**	In this lecture, I will start with explaining how analog sound signal is digitized, filtered, encoded and decoded. Next, Physiological basic speech production as well as hearing is presented, followed by principle of analysis-synthesis of speech signal.			

Course Details:

Module 1: Basic physics of sound, analog and digital signals, Analog to digital/digital to analog conversion frequency and the Fourier transform, the sampling theorem, Basic of digital filter production and perception of speech signal, basic codes of speech signal Linear prediction coding and CELP**. [10H]**

Text/ Reference books:

1. S. Tempelaars, Signal Processing, Speech and Music (Studies on New Music Research), First Edition, Routledge, 1996.
2. B. Gold, and M. Nelson, Speech and Audio Signal Processing: Processing and Perception of Speech and Music, Second Edition, John Wiley & Sons, Inc. New York, NY, USA, 2011.
3. J. Beauchamp, Analysis, Synthesis, and Perception of Musical Sounds: The Sound of Music (Modern Acoustics and Signal Processing), Springer, 2006.
4. S. V. Vaseghi, Multimedia Signal Processing: Theory and Applications in Speech, Music and Communications, John Wiley & Sons, 2007.

Course Title	:	Selected Topics in Cyber Security			
Course Code	:	EM609e	**Course Type**	:	EMF
Contact Hours	:	L- 10 T- 0 P- 0	**Credit**	:	1
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	This course will discuss principles of data and technology that frame and define cyber security. Learners will gain insight into the importance of cyber security and explore foundational cyber security principles, security architecture and emerging IT and IS technologies.			

Course Details:

Module 1: Basic concepts: threats, vulnerabilities, controls; risk; confidentiality, integrity, availability etc. Cryptographic background for Applied Cyber Security, Public-key infrastructure, New Crypto Currency, History of Digital-money including basic techniques, Bitcoin as a new Crypto Currency, Web-Forensic, Forensic vs. Anti-forensic in Biometrics, Mobile Security, Network-Storage Security including Secret Sharing, Mathematical & coding theory background, Network Security including malware, BotNet-prevention. **[10H]**

Text/ Reference books:

1. N. Godbole and S. Belapur, Cyber Security, Wiley, 2011.
2. P. Warren, Cybersecurity and Cyberwar: What Everyone Needs to Know, Oxford University Press, 2014.
3. http://www.cl.cam.ac.uk/~rja14/book.html
4. http://www.freetechbooks.com/information-security-f52.html

Course Title	:	Computational Number Theory and Cryptography			
Course Code	:	EM609g	**Course Type**	:	EMF
Contact Hours	:	L- 20 T- 0 P- 0	**Credit**	:	2
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	This course provides fundamental concepts of computational number theory and applications of number theory in cryptography with emphasis on computability.			

Course Details:

Module 1: Computational complexity, GCD computations, finite fields, modular arithmetic. **[10H]**

Module 2: Integer factorization, discrete logarithmic, Decisional Bilinear Diffie-Hellman Problem public key cryptography, hash function and digital signature. **[10H]**

Text/ Reference books:

1. W. Stallings, Cryptography and Network Security: Principles and Practice, Fifth Edition, Prentice Hall, 2011.
2. C. Kaufman, R. Perlman, M. Speciner, Network Security, Second Edition, Pearson Education, 2006.
3. B. A. Forouzan, Cryptography and Network Security, Tata McGraw Hill, 2007.
4. A. D. Rubin, White Hat Security Arsenal: Tackling the Threats, Addison-Wesley, 2001.

<table>
<tr><td>Course Title</td><td>:</td><td colspan="4">Elementary Number Theory</td></tr>
<tr><td>Course Code</td><td>:</td><td>EM609h</td><td>Course Type</td><td>:</td><td>EMF</td></tr>
<tr><td>Contact Hours</td><td>:</td><td>L- 2 T- 0 P- 0</td><td>Credit</td><td>:</td><td>2</td></tr>
<tr><td>Program/Semester</td><td>:</td><td colspan="4">UG/PG, I/ II</td></tr>
<tr><td>Pre-requisites</td><td>:</td><td colspan="4">None</td></tr>
<tr><td>Evaluation Scheme</td><td>:</td><td colspan="4">Mid-Term (30%), End Term (70%) (Tentative)</td></tr>
<tr><td>Learning Objective</td><td>:</td><td colspan="4">This course provides fundamental concepts of computational number theory and applications of number theory in cryptography with emphasis on computability.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Course Details:</td></tr>
<tr><td colspan="6">Module 1: Well ordering property, divisibility of integers, GCD computations, finite fields, modular arithmetic, linear congruence, Chinese remainder theorem. [10H]

Module 2: Integer factorization, Primality testing, Quadratic Residues, Legendre and Jacobi Symbols, Discrete logarithmic, Decisional Bilinear Diffie-Hellman Problem. [10H]</td></tr>
<tr><td colspan="6">Text/ Reference books:

1. David M. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill, 2017.
2. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, An Introduction to the Theory of Numbers, Fifth Edition, John Wiley & Sons, 1991.</td></tr>
</table>

Course Title	:	Software Quality Assurance			
Course Code	:	EM668g	**Course Type**	:	EMF
Contact Hours	:	L- 1 T- 0 P- 0	**Credit**	:	1
Program/Semester	:	UG/PG, I/ II			
Pre-requisites	:	**None**			
Evaluation Scheme	:	Mid-Term (30%), End Term (70%) (Tentative)			
Learning Objective	:	Understanding the overview and practical techniques in software quality assurance, especially review, testing and measurement.			

Course Details:

Module 1: Quality Assurance and Review in Software Engineering. Software Testing, testing techniques, software measurement, GQM, Future of Software Quality Assurance. **[10H]**

Text/ Reference books:

1. Paul C Jorgensen, Software Testing – A Craftsman's Approach, 4nd Edition CRC Press, 2013.
2. Pankaj Jalote, Integrated Approach to Software Engineering, 3rd Edition, Narosa, 2007.
3. Glenford J. Myers, Corey Sandler, Tom Badgett – The art of Software Testing, 3rd Edition Wiley, 2011.
4. Mauro Pezze, Michal Young, Software Testing and Analysis: Process, Principles and Techniques, Wiley, 2008.