Department of Computer Science and Engineering

Curriculum of B. Tech. (Computer Science and Engineering)

FIRST SEMESTER
(COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T-P	Credits
1	MA 101	Mathematics – I		3-1-0	4
2	PH 101	Physics – I		3-1-0	4
3	CY 101	Chemistry		3-1-0	4
4	EE 100	Basic Electrical Technology	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environmental and Safety Engineering			
6	PH 170	Physics Laboratory	OR	0-0-3	2
	CY 170	Chemistry Laboratory			
7	CS 171	Computing Laboratory – I		0-0-3	2
8	CE 171	Engineering Drawing		0-0-3	2
9	WS 171	Workshop Practice – I		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
		TOTAL		**15-5-15**	**30**

SECOND SEMESTER
(COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T-P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithms		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Technology			
5	CE 130	Environmental and Safety Engineering	OR	3-1-0	4
	CE 100	Engineering Mechanics			
6	CY 170	Chemistry Laboratory	OR	0-0-3	2
	PH 170	Physics Laboratory			
7	CS 172	Computing Laboratory – II		0-0-3	2
8	ME 170	Machine Drawing and Solid Modeling		0-0-3	2
9	ME 172	Workshop Practice – II		0-0-3	2
10		Extra Academic Activity – II		0-0-3	2
		TOTAL		**15-5-15**	**30**

THIRD SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CS 211	Discrete Mathematics	3-1-0	4
3	CS 241	Analog Electronics	3-0-0	3
4	CS 243	Digital Electronics	3-0-0	3
5		HS and Open Elective – I	3-0-0	3
6	CS 271	Data Structure Laboratory	0-0-3	2
7	EE 270	Basic Electrical Engineering Laboratory OR	0-0-3	2
	EC 270	Basic Electronics Laboratory		
8	CS 273	Digital Electronics Laboratory	0-0-3	2
9	MA 270	Numerical Methods Laboratory OR	0-0-3	2
	HS 270	Language Laboratory		
		TOTAL	**15-2-12**	**25**

FOURTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	MA 202	Mathematics – IV	3-1-0	4
2	CS 222	Database Management Systems	3-0-0	3
3	CS 242	Computer Organization and Architecture	3-1-0	4
4		Professional Elective – I	3-0-0	3
5		HS and Open Elective – II	3-0-0	3
6	CS 272	Database Laboratory	0-0-3	2
7	CS 274	VHDL Programming Laboratory	0-0-3	2
8	EE 270	Basic Electrical Engineering Laboratory OR	0-0-3	2
	EC 270	Basic Electronics Laboratory		
9	MA 270	Numerical Methods Laboratory OR	0-0-3	2
	HS 270	Language Laboratory		
		TOTAL	**15-2-12**	**25**

FIFTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	CS 321	Data Communication	3-0-0	3
2	CS 331	Theory of Computation	3-1-0	4
3	CS 341	Microprocessors and Microcontrollers	3-1-0	4
4		Professional Elective – II	3-0-0	3
5		HS and Open Elective – III	3-0-0	3
6	CS 371	Data Communication Laboratory	0-0-3	2
7	CS 373	Microprocessor Laboratory	0-0-3	2
8		Elective Laboratory – I	0-0-3	2
9		Elective Laboratory – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

SIXTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	CS 312	Systems Analysis and Design	3-0-0	3
2	CS 334	Operating Systems Design	3-0-0	3
3		Professional Elective – III	3-1-0	4
4		Professional Elective – IV	3-1-0	4
5		HS and Open Elective – IV	3-0-0	3
6	CS 374	Operating Systems Laboratory	0-0-3	2
7	CS 372	Systems Analysis and Design Laboratory	0-0-3	2
8		Elective Laboratory – III	0-0-3	2
9		Elective Laboratory – IV	0-0-3	2
		TOTAL	**15-2-12**	**25**

SEVENTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	CS 421	Computer Networks	3-0-0	3
2		Professional Elective – V	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		Professional Elective – VII	3-1-0	4
5		HS and Open Elective – V	3-0-0	3
6	CS 471	Network Laboratory	0-0-3	2
7	CS 491	Research Project – I	0-0-6	4
8	CS 493	Seminar and Technical Writing – I	0-0-3	2
9	CS 495	Short term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-3-12**	**28**

EIGHTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	CS 412	Software Engineering	3-1-0	4
2		Professional Elective – VIII	3-1-0	4
3		Professional Elective – IX	3-1-0	4
4		HS and Open Elective – VI	3-0-0	3
5	CS 472	Software Engineering Laboratory	0-0-3	2
6	CS 492	Research Project – II	0-0-9	6
7	CS 494	Seminar and Technical Writing – II	0-0-3	2
8	CS 496	Comprehensive viva – voce	0-0-0	2
		TOTAL	**12-3-15**	**27**

LIST OF PROFESSIONAL ELECTIVES

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	CS 213	Principles of Programming Languages	3-1-0	4
2.	CS 313	Simulation and Modeling	3-0-0	3
3.	CS 315	Optimization Techniques	3-1-0	4
4.	CS 325	Cryptographic Foundations	3-0-0	3
5.	CS 332	Algorithm Analysis and Design	3-1-0	4
6.	CS 335	Computer Graphics and Multimedia	3-1-0	4
7.	CS 336	Digital Signal Processing	3-1-0	4
8.	CS 338	Systems Software	3-0-0	3
9.	CS 375	Computer Graphics Laboratory	0-0-3	2
10.	CS 376	Digital Signal Processing Laboratory	0-0-3	2
11.	CS 377	Computational Statistics Laboratory	0-0-3	2
12.	CS 378	Systems Programming Laboratory	0-0-3	2
13.	CS 379	Network Design and Simulation Laboratory	0-0-3	2
14.	CS 384	Algorithm Analysis and Design Laboratory	0-0-3	2
15.	CS 391	Special Topics in Computer Science - I	3-1-0	4
16.	CS 392	Special Topics in Computer Science - II	3-1-0	4
17.	CS 393	Special Laboratory in Comp. Sc. Engg - I	0-0-3	2
18.	CS 394	Special Laboratory in Comp. Sc. Engg - II	0-0-3	2
19.	CS 395	Engineering Product Development Project - I	0-0-6	4
20.	CS 396	Engineering Product Development Project - II	0-0-6	4
21.	CS 413	Advanced Programming Skills	3-0-0	3
22.	CS 414	Software Project, Process and Quality Management	3-1-0	4
23.	CS 416	Bioinformatics	3-1-0	4
24.	CS 417	Graph Theory and Network Algorithms	3-0-0	3
25.	CS 418	Real Time Systems	3-1-0	4
26.	CS 423	Ad-hoc and Wireless Networks	3-1-0	4
27.	CS 425	Data Mining and Data Warehousing	3-1-0	4
28.	CS 427	Network Security	3-1-0	4
29.	CS 430	Information Theory and Coding	3-1-0	4
30.	CS 431	Compiler Design	3-0-0	3
31.	CS 432	Distributed Operating Systems	3-1-0	4
32.	CS 434	Image Processing	3-0-0	3
33.	CS 435	Artificial Intelligence	3-0-0	3
34.	CS 437	Soft Computing	3-0-0	3
35.	CS 438	Pattern Recognition	3-1-0	4
36.	CS 439	Computer Vision	3-0-0	3
37.	CS 441	Advanced Computer Architecture	3-1-0	4
38.	CS 443	Embedded Systems	3-1-0	4
39.	CS 444	Cluster and Grid Computing	3-1-0	4
40.	CS 445	Parallel Algorithms	3-1-0	4
41.	CS 449	VLSI System Design	3-1-0	4
42.	CS 473	Real Time Systems Laboratory	0-0-3	2

43.	CS 474	Image Processing Laboratory	0-0-3	2
44.	CS 477	Soft Computing Laboratory	0-0-3	2
45.	CS 478	Parallel Computing Laboratory	0-0-3	2
46.	CS 479	Advanced Linux Programming Laboratory	0-0-3	2
47.	CS 481	Compiler Design Laboratory	0-0-3	2
48.	CS 482	Distributed Computing Laboratory	0-0-3	2
49.	CS 485	Artificial Intelligence Laboratory	0-0-3	2
50.	CS 489	Computer Vision Laboratory	0-0-3	2
51.	EC 314	Digital Communication	3-0-0	3
52.	EC 322	Embedded Systems	3-0-0	3
53.	EC 370	Embedded Systems Laboratory	0-0-3	2
54.	EC 411	Coding Theory and Secure Communication	3-0-0	3
55.	EC 413	Optical Communication	3-1-0	4
56.	EC 414	Information Theory and Coding	3-1-0	4
57.	EC 415	Mobile Communication	3-1-0	4
58.	EC 421	Digital VLSI Design	3-1-0	4
59.	EC 423	HDL and High Level VLSI	3-1-0	4
60.	EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4
61.	EC 443	Digital Image Processing	3-0-0	3
62.	EC 444	Soft Computing	3-1-0	4
63.	EC 446	Adaptive Signal Processing	3-1-0	4
64.	EC 448	Evolutionary Computing Techniques	3-1-0	4
65.	EC 471	Optical communication Laboratory	0-0-3	2
66.	EC 472	Image Processing Laboratory	0-0-3	2
67.	EC 473	High Level VLSI Laboratory	0-0-3	2
68.	EC 475	VLSI Laboratory	0-0-3	2
69.	EC 477	Mobile Communication Laboratory	0-0-3	2
70.	EE 456	Robotics and Computer Vision	3-0-0	3
71.	MA 517	Lie Algebra	3-1-0	4
72.	MA 518	Advanced Complex Analysis	3-1-0	4
73.	MA 521	Combinatorics	3-1-0	4
74.	MA 523	Discrete Mathematics	3-1-0	4
75.	MA 524	Statistical Methods	3-1-0	4
76.	MA 524	Statistical Methods	3-1-0	4
77.	MA 525	Ergodic Theory	3-1-0	4
78.	MA 527	Fractals	3-1-0	4
79.	MA 529	Information Theory	3-1-0	4
80.	MA 534	Geometry of Robotics	3-1-0	4
81.	MA 548	Field Theory	3-1-0	4
82.	MA 550	Coding Theory	3-1-0	4
83.	MA 552	Fuzzy logic and Set Theory	3-1-0	4
84.	MA 553	Optimization Techniques	3-1-0	4
85.	MA 555	Stochastic Processes	3-1-0	4
86.	MA 556	Number Theory	3-1-0	4

Department of Computer Science and Engineering

SUMMARY OF COURSES

Sub Discipline: **Software Engineering**

CS 211	Discrete Mathematics	3-1-0	4
CS 213	Principles of Programming Languages	3-1-0	4
CS 312	Systems Analysis and Design	3-0-0	3
CS 313	Simulation and Modeling	3-0-0	3
CS 315	Optimization Techniques	3-1-0	4
CS 412	Software Engineering	3-1-0	4
CS 413	Advanced Programming Skills	3-0-0	3
CS 414	Software Project, Process and Quality Management	3-1-0	4
CS 416	Bioinformatics	3-1-0	4
CS 417	Graph Theory and Network Algorithms	3-0-0	3
CS 418	Real Time Systems	3-1-0	4

Sub Discipline: **Network and Secured Computing**

CS 222	Database Management Systems	3-0-0	3
CS 321	Data Communication	3-0-0	3
CS 325	Cryptographic Foundations	3-0-0	3
CS 326	Data Communication and Computer Networks	3-0-0	3
CS 327	Relational Database Management Systems	3-0-0	3
CS 421	Computer Networks	3-0-0	3
CS 423	Ad-hoc and Wireless Networks	3-1-0	4
CS 425	Data Mining and Data Warehousing	3-1-0	4
CS 427	Network Security	3-1-0	4

Sub Discipline: **Intelligent Computing and Computer Vision**

CS 102	Data Structures and Algorithms	3-1-0	4
CS 331	Theory of Computation	3-1-0	4
CS 332	Algorithm Analysis and Design	3-1-0	4
CS 333	Operating Systems	3-0-0	3
CS 334	Operating Systems Design	3-0-0	3
CS 335	Computer Graphics and Multimedia	3-1-0	4
CS 336	Digital Signal Processing	3-1-0	4
CS 338	Systems Software	3-0-0	3
CS 430	Information Theory and Coding	3-1-0	4
CS 431	Compiler Design	3-0-0	3
CS 432	Distributed Operating Systems	3-1-0	4
CS 433	Algorithm Design	3-0-0	3
CS 434	Image Processing	3-0-0	3

CS 435	Artificial Intelligence	3-0-0	3
CS 437	Soft Computing	3-0-0	3
CS 438	Pattern Recognition	3-1-0	4
CS 439	Computer Vision	3-0-0	3

Sub Discipline: Computer Hardware

CS 241	Analog Electronics	3-0-0	3
CS 242	Computer Organization and Architecture	3-1-0	4
CS 243	Digital Electronics	3-0-0	3
CS 341	Microprocessors and Microcontrollers	3-1-0	4
CS 343	Digital Logic Design	3-0-0	3
CS 441	Advanced Computer Architecture	3-1-0	4
CS 442	Computer System Architecture	3-0-0	3
CS 443	Embedded Systems	3-1-0	4
CS 444	Cluster and Grid Computing	3-1-0	4
CS 445	Parallel Algorithms	3-1-0	4
CS 449	VLSI System Design	3-1-0	4

Sub Discipline: Laboratory Courses

CS 171	Computing Laboratory – I	0-0-3	2
CS 172	Computing Laboratory – II	0-0-3	2
CS 271	Data Structure Laboratory	0-0-3	2
CS 272	Database Laboratory	0-0-3	2
CS 273	Digital Electronics Laboratory	0-0-3	2
CS 274	VHDL Programming Laboratory	0-0-3	2
CS 371	Data Communication Laboratory	0-0-3	2
CS 372	Systems Analysis and Design Laboratory	0-0-3	2
CS 373	Microprocessor Laboratory	0-0-3	2
CS 374	Operating Systems Laboratory	0-0-3	2
CS 375	Computer Graphics Laboratory	0-0-3	2
CS 376	Digital Signal Processing Laboratory	0-0-3	2
CS 377	Computational Statistics Laboratory	0-0-3	2
CS 378	Systems Programming Laboratory	0-0-3	2
CS 379	Network Design and Simulation Laboratory	0-0-3	2
CS 384	Algorithm Analysis and Design Laboratory	0-0-3	2
CS 471	Network Laboratory	0-0-3	2
CS 472	Software Engineering Laboratory	0-0-3	2
CS 473	Real Time Systems Laboratory	0-0-3	2
CS 474	Image Processing Laboratory	0-0-3	2
CS 477	Soft Computing Laboratory	0-0-3	2
CS 478	Parallel Computing Laboratory	0-0-3	2
CS 479	Advanced Linux Programming Laboratory	0-0-3	2
CS 481	Compiler Design Laboratory	0-0-3	2
CS 482	Distributed Computing Laboratory	0-0-3	2

| CS 485 | Artificial Intelligence Laboratory | 0-0-3 | 2 |
| CS 489 | Computer Vision Laboratory | 0-0-3 | 2 |

Sub Discipline: **Project, Seminar and Special Courses**

CS 391	Special Topics in Computer Science - I	3-1-0	4
CS 392	Special Topics in Computer Science - II	3-1-0	4
CS 393	Special Laboratory in Comp. Sc. Engg - I	0-0-3	2
CS 394	Special Laboratory in Comp. Sc. Engg - II	0-0-3	2
CS 395	Engineering Product Development Project - I	0-0-6	4
CS 396	Engineering Product Development Project - II	0-0-6	4
CS 491	Research Project – I	0-0-6	4
CS 492	Research Project – II	0-0-9	6
CS 493	Seminar and Technical writing – I	0-0-3	2
CS 494	Seminar and Technical Writing – II	0-0-3	2
CS 495	Short term Industrial/Research Experience	0-0-0	2
CS 496	Comprehensive viva – voce	0-0-0	2

COURSES OFFERED AS OPEN ELECTIVES
(Normally not offered to the students of Computer Science & Engineering)

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	CS 312	Systems Analysis and Design	3-0-0	3
2.	CS 313	Simulation and Modeling	3-0-0	3
3.	CS 325	Cryptographic Foundations	3-0-0	3
4.	CS 326	Data Communication and Computer Networks	3-0-0	3
5.	CS 327	Relational Database Management Systems	3-0-0	3
6.	CS 333	Operating Systems	3-0-0	3
7.	CS 343	Digital Logic Design	3-0-0	3
8.	CS 413	Advanced Programming Skills	3-0-3	3
9.	CS 417	Graph Theory and Network Algorithms	3-0-0	3
10.	CS 433	Algorithm Design	3-0-0	3
11.	CS 434	Image Processing	3-0-0	3
12.	CS 435	Artificial Intelligence	3-0-0	3
13.	CS 437	Soft Computing	3-0-0	3
14.	CS 439	Computer Vision	3-0-0	3
15.	CS 442	Computer System Architecture	3-0-0	3

DETAILED SYLLABI OF COURSES

CS 102	Data Structures and Algorithms	3-1-0	4
CS 171	Computing Laboratory – I	0-0-3	2
CS 172	Computing Laboratory – II	0-0-3	2
CS 211	Discrete Mathematics	3-1-0	4
CS 213	Principles of Programming Languages	3-1-0	4
CS 222	Database Management Systems	3-0-0	3
CS 241	Analog Electronics	3-0-0	3
CS 242	Computer Organization and Architecture	3-1-0	4
CS 243	Digital Electronics	3-0-0	3
CS 271	Data Structure Laboratory	0-0-3	2
CS 272	Database Laboratory	0-0-3	2
CS 273	Digital Electronics Laboratory	0-0-3	2
CS 274	VHDL Programming Laboratory	0-0-3	2
CS 312	Systems Analysis and Design	3-0-0	3
CS 313	Simulation and Modeling	3-0-0	3
CS 315	Optimization Techniques	3-1-0	4
CS 321	Data Communication	3-0-0	3
CS 325	Cryptographic Foundations	3-0-0	3
CS 326	Data Communication and Computer Networks	3-0-0	3
CS 327	Relational Database Management Systems	3-0-0	3
CS 331	Theory of Computation	3-1-0	4
CS 332	Algorithm Analysis and Design	3-1-0	4
CS 333	Operating Systems	3-0-0	3
CS 334	Operating Systems Design	3-0-0	3
CS 335	Computer Graphics and Multimedia	3-1-0	4
CS 336	Digital Signal Processing	3-1-0	4
CS 338	Systems Software	3-0-0	3
CS 341	Microprocessors and Microcontrollers	3-1-0	4
CS 343	Digital Logic Design	3-0-0	3
CS 371	Data Communication Laboratory	0-0-3	2
CS 372	Systems Analysis and Design Laboratory	0-0-3	2
CS 373	Microprocessor Laboratory	0-0-3	2
CS 374	Operating Systems Laboratory	0-0-3	2
CS 375	Computer Graphics Laboratory	0-0-3	2
CS 376	Digital Signal Processing Laboratory	0-0-3	2
CS 377	Computational Statistics Laboratory	0-0-3	2
CS 378	Systems Programming Laboratory	0-0-3	2
CS 379	Network Design and Simulation Laboratory	0-0-3	2
CS 384	Algorithm Analysis and Design Laboratory	0-0-3	2
CS 391	Special Topics in Computer Science - I	3-1-0	4
CS 392	Special Topics in Computer Science - II	3-1-0	4
CS 393	Special Laboratory in Comp. Sc. Engg - I	0-0-3	2
CS 394	Special Laboratory in Comp. Sc. Engg - II	0-0-3	2

CS 395	Engineering Product Development Project - I	0-0-6	4
CS 396	Engineering Product Development Project - II	0-0-6	4
CS 412	Software Engineering	3-1-0	4
CS 413	Advanced Programming Skills	3-0-0	3
CS 414	Software Project, Process and Quality Management	3-1-0	4
CS 416	Bioinformatics	3-1-0	4
CS 417	Graph Theory and Network Algorithms	3-0-0	3
CS 418	Real Time Systems	3-1-0	4
CS 421	Computer Networks	3-0-0	3
CS 423	Ad-hoc and Wireless Networks	3-1-0	4
CS 425	Data Mining and Data Warehousing	3-1-0	4
CS 427	Network Security	3-1-0	4
CS 430	Information Theory and Coding	3-1-0	4
CS 431	Compiler Design	3-0-0	3
CS 432	Distributed Operating Systems	3-1-0	4
CS 433	Algorithm Design	3-0-0	3
CS 434	Image Processing	3-0-0	3
CS 435	Artificial Intelligence	3-0-0	3
CS 437	Soft Computing	3-0-0	3
CS 438	Pattern Recognition	3-1-0	4
CS 439	Computer Vision	3-0-0	3
CS 441	Advanced Computer Architecture	3-1-0	4
CS 442	Computer System Architecture	3-0-0	3
CS 443	Embedded Systems	3-1-0	4
CS 444	Cluster and Grid Computing	3-1-0	4
CS 445	Parallel Algorithms	3-1-0	4
CS 449	VLSI System Design	3-1-0	4
CS 471	Network Laboratory	0-0-3	2
CS 472	Software Engineering Laboratory	0-0-3	2
CS 473	Real Time Systems Laboratory	0-0-3	2
CS 474	Image Processing Laboratory	0-0-3	2
CS 477	Soft Computing Laboratory	0-0-3	2
CS 478	Parallel Computing Laboratory	0-0-3	2
CS 479	Advanced Linux Programming Laboratory	0-0-3	2
CS 481	Compiler Design Laboratory	0-0-3	2
CS 482	Distributed Computing Laboratory	0-0-3	2
CS 485	Artificial Intelligence Laboratory	0-0-3	2
CS 489	Computer Vision Laboratory	0-0-3	2
CS 491	Research Project – I	0-0-6	4
CS 492	Research Project – II	0-0-9	6
CS 493	Seminar and Technical writing – I	0-0-3	2
CS 494	Seminar and Technical Writing – II	0-0-3	2
CS 495	Short term Industrial/Research Experience	0-0-0	2
CS 496	Comprehensive viva – voce	0-0-0	2

CS 102   DATA STRUCTURES AND ALGORITHMS   4 credits [3-1-0]

Prerequisites: NIL

Introduction: Data types, Abstract data types, data Structures, storage structure, Concept of 'O' notation, Time complexity & Space complexity issues. Arrays, Stacks & recursions, Queues, Linked list, Hashing, Trees Graphs & their Applications Linked representation of Graph, Adjacency Matrix, Adjacency list, Shortest path algorithm, Graph Traversal: BFS, DFS, BDD and its application ,Sorting Techniques **:** Bubble sort, Quick sort, selection sort, Heap sort, insertion sort, merge sort, radix sort & efficiency considerations. Searching Techniques**:** Sequential search, index sequential search, Binary search, Interpolation Search, Tree Searching, and Fibonacci Search. Files: properties of physical storage media, file organization techniques.

Essential Reading:
1. Tremblay & Sorenson, *Introduction to Data Structures with applications*, Tata-McGraw-Hill, 2nd Ed., 2006.
2. M. A. Weiss, *Data Structures and Algorithm Analysis in C*, Addison-Wesley, 3nd Ed., 2006.

Supplementary Reading:
1. S. Sahani, *Data Structures, Algorithms and Applications in C++,* Silicon Press, 2004.
2. A. V.Aho, J. E. Hopcroft & J.D. Ullman, *Data Structures and Algorithms*, Addition-Wesley, 1998.
3. G. A. V. Pai, *Data Structures and Algorithms: Concepts, Techniques and Applications*, Tata McGraw Hill, 1st Ed, 2008.
4. D. Samanta, *Data Structures,* PHI, 2004.

CS 171   COMPUTING LABORATORY – I   2 credits [0-0-3]

Prerequisites: NIL

1. Read a line of text and count the number of characters, vowels, consonants and blank spaces in it.
2. Implementation of matrix manipulations
3. Programs on recursive function.
4. Interchanging values of two variables without a third variable using arithmetic operators and also using bit-wise operators.
5. Programs on the use of functions.
6. Programs on Sorting and Searching.
7. Programs on files for creating, populating and manipulating a simple database.
8. Implementation of linked list.
9. Implementation of other data structures.
10. Menu driven programs.

Essential Reading:
1. E. Balguruswami, *Programming with C*, Tata McGraw Hill, 3rd Ed, 2006.
2. Y. Kanetkar, *Let Us C*, BPB Publications, 3rd Ed, 2006.

CS 172   COMPUTING LABORATORY – II   2 credits [0-0-3]

Prerequisites: NIL

Implementation of:
1. Classes and objects.
2. Constructors and Destructors.
3. Friend and virtual functions.
4. Operator overloading, function overloading.
5. Conversion of one data type to another.
6. Inheritance (single, hierarchical, multiple and multilevel).
7. Templates.
8. Exception handling.

Essential Reading:
1. E. Balguruswami, *Programming with C++*, Tata McGraw Hill, 3rd ed, 2006
2. R. Lafore, *Turbo C++,* Galgotia Publications, 3rd Ed, 2006.

CS 211   DISCRETE MATHEMATICS   4 credits [3-1-0]

Prerequisites: NIL

Sets and Propositions: Mathematical induction, The Principle of Inclusion and Exclusion, Proposition, Theory of inference, Predicate Calculus, Methods of proof, Permutations and Combinations, Relations and Functions: properties of binary relations, Closure of relations, Warshall's algorithm, Equivalence relations Partial ordering relations and lattices, Chains and antichains, Functions, Composition of Functions, Invertible Functions, Recursive Functions, Pigeonhole principle, Graphs: representation of Graphs, operations on graphs, paths and circuits, graph traversals, shortest path in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Traveling sales persons problem, Planar graphs, Graph Coloring, Application of Graphs, Tress and Cut-Sets: Rooted trees, Binary search trees, Spanning trees, Minimum spanning trees, Kruskal's Algorithm, Prims Algorithm, Transport Network, Modelling Computation: Languages, Phase structure and grammars, Types of grammars and Languages, Finite state machines, Discrete Numeric functions and Generating Functions, Recurrence relations and recursive algorithms, Linear recurrence relations, Solving Recurrence Relations by Generating Functions, Divide and conquer algorithms, Groups and rings: groups and subgroups, Cosets and Lagrange's theorem, Codes and Group codes, Boolean Algebras: Lattices and algebraic systems, Principle of duality, Distributive and complemented lattices, Boolean functions and Boolean expressions, Simplification of logic expressions using Karnaugh Map, Simplification of logic expressions using Quine-McClusky method, Propositional Calculus, Design and Implementation of Digital Networks, Switching Circuits.

Essential Reading:
1. C. L. Liu, D. P. Mohapatra, *Elements of Discrete Mathematics: A computer Oriented Approach*, Tata-McGraw Hill, 3rd Ed, 2008.
2. B. Kolman and R.C.Busby, *Discrete Mathematical Structures for Computer Science*, Prentice Hall of India, 5th Ed, 2002.

Supplementary Reading:
1. Kenneth H. Rosen, *Discrete Mathematics and its Applications*, Tata McGraw Hill, 5th ed, 2003.
2. J. P. Tremblay and R. Manohar, *Discrete Mathematical Structures with Applications*, to Computer Science,Tata Mc-Graw Hill, 2001.
3. Joe L. Mott, A. Kandel, and T. P. Baker, *Discrete Mathematics for Computer Scientists & Mathematics*, Prentice Hall of India, 2nd ed, 2006.
4. N. Deo, *Graph Theory with applications to Engineering & Computer Science*, Prentice Hall of India, 2006.
5. S. Lipschutz, *Discrete Mathematics*, Tata McGraw Hill, 2005.

CS 213　　　　PRINCIPLES OF PROGRAMMING LANGUAGES　　　　4 credits [3-1-0]

Prerequisites: CS 171 & CS 172

The Role of Programming Languages: Toward Higher-level Languages, Problems of Scale, Programming Paradigms, Language Implementation Bridging the Gap Language Description:- Syntactic Structure: Expression Notations, Abstract Syntax Trees, Lexical Syntax, Context -Free Grammars, Grammars for Expressions, Variants of Grammars
Statements: Structured Programming, Types: Data Representation, Procedure Activations.
Object Oriented Programming: Groupings of Data and Operations:- Constructs fro Program Structuring, Information Hiding, Program Design with Modules, Modules and Defined Types, Class Declarations in C++, Dynamic Allocation I C++, Templates: Parameterized Types, Implementation of Objects in C++.7. Object-Oriented Programming:- What is an Object?, Object-Oriented Thinking, Inheritance, Object-Oriented Programming in C++, An extended C++ example, Derived Classes and information Hiding, Objects in Smalltalk, Smalltalk Objects have self.
Functional programming: Elements of Functional Programming, functional Programming in a Typed Languages, functions as First-Class Values, ML, Functional Programming with Lists
Other Paradigms: Logic Programming, an Introduction to Concurrent Programming

Essential Reading:
1. R. Sethi, Programming Languages – Concepts & Constructs, Pearson Education.

Supplementary Reading:
1. R. W. Sebesta, Concepts of Programming Languages, 8th edition, Addison-Wesley, 2007.
2. M. L. Scott, Programming Language Pragmatics, 2nd edition, Morgan Kaufmann, 2005.
3. T. W. Pratt and Marvin V. Zelkowitz Programming Languages: Design and Implementation, 4th edition, Prentice-Hall, 2001.
4. S. Krishnamurthi, Programming Languages: Application and Intepretation, Creative Commons Attribution-Non Commercial-Share Alike 3.0, Version:
http*://www.cs.brown.edu/~sk/Publications/Books/ProgLangs/2007-04-26*

CS 222   DATABASE MANAGEMENT SYSTEMS   3 credits [3-0-0]

Prerequisites: NIL

Introduction to Database systems: Data Independence, Data Models, levels of abstraction, structure of DBMS, Relational Model, Integrity constraints, Relational Languages, Query Languages: SQL, QUEL, QBE, Aggregate operators, Embedded and Dynamic SQL. File Organization: Storage, Buffer management, Record and page formats, File organization techniques, Indexing. Query optimization: Query processing on various operations, Translating SQL queries, estimating the cost. Database design: E-R Model, Functional dependencies, normalization, multi-valued dependencies. Concurrency control and recovery: transaction, schedules, Lock based concurrency, Lock management, Concurrency control without locking, Crash recovery- log, check pointing, media recoveries. Database Security, Distributed databases design, Object Oriented database design & its implementation, Introduction to recent advances in database technology.

Essential Reading:
1. J. D. Ullman, *Principles of Data Base Systems, Galgotia*, 2nd ed, 2003.
2. A.Silberschatz, H.F. Korth & A. Sudarshan, *Database system Concepts*, McGraw Hill, 5th ed, 2006.

Supplementary Reading:
1. B. Desai, *An Introduction to database system*, Galgotia, 1997.
2. C. J. Date: *An introduction to Data Base Systems*, Addison Wesley, 1995.
3. R. Elmasri, S. Navathe, S. B. Navathe, R. Sunderraman, *Fundamentals of Database Systems*, Addison Wesley, 2nd ed, 1994
4. R.R. Krishnan, Database Management Systems, McGraw Hill, reprint 2007

CS 241   ANALOG ELECTRONICS   4 credits [3-0-0]

Prerequisites: NIL

Bipolar Junction Transistors and Field Effect Transistors, Biasing for BJT/FET and thermal stabilisation, transistors at low frequencies, small signal equivalent circuits, linear analysis. Feedback Amplifier Classifications, input and output resistance of feed back amplifiers, Effect of feedback on gain and impedance, frequency response of feed back amplifiers; emitter and source follower; low frequency response, h-parameters; transistors at high frequencies, high frequency equivalent circuit and response, gain-BW product. Crystal, Wien bridge and tuned oscillators, Multi stage amplifiers, Distortion in amplifiers. OP-amp bias currents and offset voltages, frequency response, measurement of OP-amp parameters, coupled amplifier, Class A and Class B power amplifiers; push –pull amplifiers; distortion in Class AB push-pull amplifiers; audio power amplifier, Class C amplifiers.

Essential Reading:
1. Malvino & D. J. Bates, *Electronics Principles*, Tata McGraw Hill, 7th Ed, 2007.
2. J. Millman, C. C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, Tata McGraw Hill, 35th reprint, 2004.

Supplementary Reading:
1. Boylested & Nashelsky, *Electronic Devices and Circuit Theory,* Prentice Hall of India, 7th Ed, 2007.
2. D. A. Bell, Electronic Devices and Circuits, Prentice Hall of India, 4th Ed, 2004.
3. J. Millman, *Microelectronics*, McGraw Hill, 2nd Ed, 1988.

CS 242 COMPUTER ORGANIZATION AND ARCHITECTURE 4 credits [3-1-0]

Prerequisites: NIL

Overview of Computer Architecture and Organization: Contrast between computer architecture and organization; Fundamentals of computer architecture: Organization of von Neumann machine; Instruction format; execution cycle; Instruction types and addressing modes; Computer Arithmetic: representation of integers and real numbers; algorithm for carrying out common integer and floating-point operation; Memory system organization and architecture: Memory system hierarchy; main memory organization; cache memory; virtual memory; Interfacing and Communication: I/O fundamentals; I/O techniques; Interrupt; memory system design and Interfacing; Buses; Device subsystem: External storage system; RAID architecture; Control Unit Design: Instruction sequencing, Instruction interpretation, control memory, Hardwired Control, Micro programmed Control, Micro programmed Computers. I/O organization: Bus control, Serial I/O (study of Asynchronous and synchronous modes, USART & VART), Parallel Data transfer: (Program controlled: Asynchronous, synchronous & Interrupt driven modes, DMA mode, interrupt controller and DMA controller). Organization of CPU: Single vs multiple data path; ISA; Control unit; Instruction pipelining; Trends in computer architecture: CISC, RISC, VLIW, Introduction to ILP; Pipeline Hazards: Structural, data and control; Reducing the effects of hazards.

Essential Reading:
1. V. C. Hamacher, Z. G. Veranesic, and S. G. Zaky, *Computer Organisation*, Tata McGraw Hill, 5th Ed, 2002.
2. J. P. Hayes, *Computer Architecture and Organisation*, McGraw Hill, 3rd Ed, 1998.

Supplementary Reading:
1. M. M. Mano, *Computer System Architecture*, Pearson, 3rd Ed, 2004.
2. W. Stallings, *Computer Organization and Architecture – Designing for Performance*, Prentice Hall of India, 7th Ed, 2007.
3. D.A. Pattersen and J.L. Hennesy, *Computer Organisation and Design: The Hardware Software Interface*, Elsevier, 2nd Ed, 2006

CS 243 DIGITAL ELECTRONICS 3 credits [3-0-0]

Quine McCluakey method of Minimization, Minimization of multiple I/O Switching functions, Design of combinational logic: few examples. Full Adder / Subtracter, BCD Adder, LAC Adder, Decoder, MUX / DEMUX three structure, Combinational logic design using ROM array, Applications of MSI designs. Difference between Combinational and Sequential circuits, Flip Flops, Counters, Shift Registers and PLA. Basic models of sequential M/C, Analysis of Asynchronous and synchronous circuits, Synthesis of completely and incompletely specified synchronous sequential M/Cs. Fault detection and location, classical methods, path senistizing method, Equivalent Normal-Form method, Two-level-circuit, fault detection, Multi-level-circuit, fault detection, Boolean difference method, SPOOF method. R-2R ladder network, Binary ladder, Examples of DAC ICs, Successive approximation ADC, Example of ICs.

Essential Reading:
1. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with VHDL Design*, Tata Mc-Graw Hill, 2005
2. S. C. Lee, *Digital Circuits & Logic Design*, Prentice Hall of India, 2001.

Supplementary Reading:
1. R. P. Jain, *Modern Digital Electronics*, Tata McGraw Hill, 3rd Ed, 2003.

CS 271   DATA STRUCTURE LABORATORY   2 credits [0-0-3]

Prerequisites: CS 102

Following is a list of experiments to be coded in C or C++. Details of each experiment are to be provided by the subject teacher.
1. Understanding the use of arrays.
2. Programming insertion, deletion, merging in arrays.
3. Realization of various linked lists.
4. Simulating a stack.
5. Using stack for various conversions of expression like prefix etc.
6. Realizing a queue.
7. Performing various operations on queue.
8. Simulate a tree and perform various tree traversals.
9. Programming various sorting algorithms.
10. Understanding the use of hashing.

CS 272   DATABASE LABORATORY   2 credits [0-0-3]

Prerequisites: CS 102

Database Lab:
1. Study of SQL syntax
2. Study of Oracle syntax
3. Study of DB2 syntax
4. Writing Views, Assertions, Triggers
5. PL/SQL Programs to be simulated given by instructor
6. Generating forms and reports

Following database to be designed and queries to be processed using SQL,
Oracle and DB2:
  i.   Order processing,
 ii.   insurance,
iii.   student enrollment,
 iv.   library,
  v.   banking enterprise;

Primary keys, data types and relevant queries for the above database will be supplied by the instructor; Front end may be created by using VB, Java.

CS 273   DIGITAL ELECTRONICS LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. To study and verify various logic gates.
2. Verification of DE-MORGAN' theorem.
3. Implementation of Boolean function using NAND and NOR logic.
4. Implementation of half and full adder circuit is using NAND logic gate.
5. To design and study RS and JK Flip-flop.
6. To study and design JK flip-flop.
7. To design module-7 counter.
8. Designing a buffer register 4 bit using D-flip flop.
9. Design a 2 to 4 line decoder using AND and NOT gates.
10. Design a decimal to binary priority encoder

CS 274   VHDL PROGRAMMING LABORATORY   2 credits [0-0-3]

Prerequisites: CS 243

1. Write VHDL code to implement the following:
2. Full adder using multiplexer
3. Binary Multiplexer (8 bit/16 bit)
4. Floating-Point addition
5. Carry save Multiplier (8 bit)
6. Two's complement Multiplier
7. Parity Encoder
8. GCD Processor
9. Universal Shift register with asynchronous reset
10. FSM to detect the flag sequence of HDLC frame

CS 312   SYSTEMS ANALYSIS AND DESIGN   3 credits [3-0-0]

Prerequisites: NIL

Concepts of data and information, System Concepts, Components of a system, Characteristics of a system, Types of systems: closed systems, open systems, man made systems. Information Systems, Types of information Systems: Transaction processing systems, Management information systems, Decision support systems, Expert systems. Computer based information systems (CBIS), Feasibility study. Systems development life cycle model, Iterative waterfall model, Prototype model, Incremental model, Spiral model. Systems Analysis and Design, Classical and Structured approaches, Structured Analysis tools: DFD, Data dictionary, Decision tree etc., Systems Design, input/output design, Software Design and Documentation tools: HIPO and Warnier / Orr Diagrams. System testing and quality assurance. System Implementation. HW/SW selection, Conversion, Software Maintenance. Activity network. CPM, PERT, Gnatt Chart, Recent trend in systems analysis and design.

Essential Reading:
1. H. George, Valacich, *Modern Systems Analysis and Design*, Pearson, 2nd Ed, 2005.
2. J. A. Senn, *Analysis and Design of Information Systems*, McGraw Hill, 1989.

Supplementary Reading:
1. H. C. Lucas, *The Analysis, Design and Implementation of Information Systems*, McGraw Hill, 1985.
2. E. M. Awad, *System Analysis & Design*, Galgotia Publication, 2002.
3. R. Mall, *Fundamentals of Software Engineering*, Prentice Hall of India, 2nd Ed, 2006.

CS 313 SIMULATION AND MODELING 3 credits [3-0-0]

Prerequisites: NIL

Definition of System: Types of Systems-continuous and discrete; Modeling process and Definition of a model; Computer workload and preparation of its model; verification and validation modeling procedures; Comparing model data with real system data; Differential and partial differential equation models; Combining discrete events and continuous models; (Examples of a computer should be used for illustration and discussion purposes). Simulation Process: Use of simulation; Discrete and continuous simulation languages (such as GPSS, SLAM, SIMSCRIPT, II and SIMULA); Study and use of one language (depending on the availability) in detail. Use of Database and A. I. techniques in the area modeling and simulation.

Essential Reading:
1. J. Banks, *Modeling and Performance Measurement of Computer Systems*, Prentice Hall of India, reprint 2007.
2. A. M. Law, W. D. Kelton, *Simulation Modelling and Analysis*, Tata McGraw Hill, 2000.

Supplementary Reading:
1. T. A. Payer, *Introduction to Simulation*, McGraw-Hill.
2. J. Reitmen, *Computer Simulation Application*, Wiley, reprint 2000.
3. W. A. Speriet, *Computer – aided Modeling and Simulation*, Academic Press, reprint 2002.

CS 315 OPTIMIZATION TECHNIQUES 4 credits [3-1-0]

Prerequisites: NIL

Origin, Characteristics and Techniques, operations research Modeling, Linear Programming Constraints with less than equal to , equal to and greater than equal to types. The Simplex method, Dual simplex method, Revised simplex method, Duality theory and sensitivity analysis. Transportation and Assignment problems, Traveling Salesman problem using branch and bound method, Network analysis including PERT-CPM, Integer programming, Non-linear programming problem solving using Fibonnacci search method, Golden ratio method, Gradient search method, Gradient projection method and Hessian matrix method, Queuing theory and applications for different M/M/I and M/M/C models. Inventory models considering holding cost, ordering cost and penalty costs.

Essential Reading:
1. H. A. Taha, *Operations Research an Introduction*, Prentice Hall of India, 8th Ed, 2007.
2. F. S. Hillier, G. J. Lieberman, *Introduction to Operation Research*, Mc-Graw-Hill, 2008.

Supplementary Reading:
1. S. S. Rao, *Optimisation Theory and applications*, Wiley Eastern Ltd. India, 1978, reprint 2005.
2. K. Swaroop, P.K. Gupta, M. M. Singh, *Operations Research*, Sultan Chand and Sons, India, 2005.
3. B. E. Gillet, *Introduction to Operation Research: a computer oriented algorithmic approach* Tata McGraw Hill, 1979, reprint 2005.

CS 321   DATA COMMUNICATION   3 credits [3-0-0]

Prerequisites: NIL

Data transmission fundamentals: historical overview; time/frequency representation of data signals; elements of a communications link; definition of key terms; factors affecting system design, Binary and multi-level signaling: information transfer rate; calculation of channel capacity; bandwidth efficiency, Baseband data transmission: the problem of inter symbol interference; achieving a Nyquist channel response; recovery of symbols from noise; bit error rate performance for baseband data systems, Bandpass digital modulation: binary modulation schemes (eg ASK, FSK, PSK); multi-level digital modulation (e.g. M-ary ASK, M-ary FSK, M-ary PSK, QAM), Coding theory and practice: source coding; channel coding; block coding; convolutional coding; combined coding and modulation, Multi-user digital modulation techniques such as frequency division multiple access (FDMA); time division multiple access (TDMA); code division multiple access (CDMA); combined multiple access systems; Error detection and correction, Digital transmission fundamental

Essential Reading:
1. B. Forouzan, *Data Communications and Networking*, Tata McGraw Hill, 4th Ed, 2007.
2. A.Leon-Garcia & I Widjaja, *Communication Networks, Fundamental Concepts & key Architecture*, Tata McGraw Hill, 2nd Ed, 2003.

Supplementary Reading:
1. F. Halsall, *Data Communication, Computer Networks and Open Systems*, Addison Wesley, 4th Ed.
2. W. Stallings, *Data and Computer Communications*, Prentice Hall of India, 8th Ed. 2007.

CS 325   CRYPTOGRAPHIC FOUNDATIONS   3 credits [3-0-0]

Prerequisites: NIL

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

Essential Reading:
1. W. Stalling, *Cryptography and Network Security: Principles and Practices*, 4th Ed, 2005
2. B. A. Forouzan, *Cryptography and Network Security,* McGraw Hill, 2nd Ed, 2004.

Supplementary Reading:
1. J. Hershey, *Cryptography Demystified*, McGraw Hill, 2003
2. R E Smith, *Internet Cryptography*, Addison Wesley
3. J. Knudsen, *Java Cryptography*, O'Reilly, 1998.

**CS 326   DATA COMMUNICATION AND COMPUTER   3 credits [3-0-0]
            NETWORK**

Prerequisites: NIL
Data transmission fundamentals: time/frequency representation of data signals; elements of a communications link; definition of key terms; Binary and multi-level signaling: information transfer rate; calculation of channel capacity; bandwidth efficiency, Baseband data transmission: the problem of inter symbol interference; achieving a Nyquist channel response; recovery of symbols from noise; bit error rate performance for baseband data systems, Advantages of Computer networks, LAN vs. WAN, ISO/ISI seven-layer architecture, networks topologies. Physical Layer: transmission media, analog transmission, digital transmission. Data Link Layer: Framing, Error detection and correction, MAC Layer : Ethernet Network Layer : Routing Algorithms – Shortest path, distance vector, link state routing, flooding, hierarchical routing, Internetworking – Tunneling, Encapsulation, Fragmentation, Virtual circuits, datagrams, Internet Protocol (IP) – Header Structure, addresses, options, etc. Routing protocols (examples: RIP, HELLO, OSPF, BGP). Classless Inter-Domain Routing, ICMP, ARP, RARP, BOOTP, DHCP. Transport Layer : Flow and error control, multiplexing, establishing and releasing a connection. Transmission Control Protocol, User Datagram Protocol, Domain Name Service.

Essential Reading:
1. B. A. Forouzan, *Data Communication and Networking*, Tata McGraw Hill, 4th Ed, 2007.
2. A. S. Tanenbaum, *Computer Networks*, Prentice Hall of India, 4th Ed, 2006.

Supplementary Reading:
1. F. Halsall, *Data Communication, Computer Networks and Open Systems*, Pearson, 2003.
2. B. A. Forouzan, *TCP/IP Protocol Suit*, Tata McGraw Hill, 3rd Ed, 2006.

CS 327   RELATIONAL DATABASE MANAGEMENT SYSTEMS   3 credits [3-0-0]

Prerequisites: NIL

Introduction to Database Systems: Goals of Data Base Management Systems, Data Independence, Data Models, Brief Review of file system, File systems vs. DBMS, Relational Languages, Structure of DBMS, Storage structures of files. Database design: ER model, Relational model and relational algebra, Relational database design, Queries in a DBMS, Basic queries in SQL, Database design issues, Functional dependencies, Normal forms. Introduction to Database security; Introduction to Object Oriented database design.

Essential Reading:
1. J. D. Ullman, *Principles of Data Base Systems, Galgotia Publisher*, New Delhi, 2003.
2. Silberschatz, H. F. Korth & A. Sudarshan, *Database system Concepts*, McGraw Hill, 5th Ed, 2006.

Supplementary Reading:
1. B. Desai, *An Introduction to database system*, Galgotia, 1997.
2. C. J. Date: *An introduction to Data Base Systems*, Addison Wesley, 1995.
3. R. Elmasri, S. Navathe, S. B. Navathe & R. Sunderraman, *Fundamentals of Database Systems*, Addison Wesley, 2nd Ed, 1994
4. Raghu Ram Krishnan, *Database Management Systems*, McGraw Hill, reprint 2007.

CS 331   THEORY OF COMPUTATION   4 credits [3-1-0]

Prerequisites: NIL

Finite Automata and Regular Expressions: Deterministic and non-deterministic finite automata, regular expressions, Two way finite automata, finite automata with output: Mealy and Moore machines; Properties of Regular Sets: Pumping lemma, closure properties,decision algorithm, MyHill- Nerode theorem and minimization of finite automata; Context-Free Grammars(CFG): CFGs, derivation trees, simplification, Chomsky normal forms, Greibach normal forms; Pushdown Automata(PDA): Definitions, relationship between PDA and context free languages; Properties of Context-Free Languages: Pumping lemma, closure properties, decision algorithm; Turing Machines: The turing machine model, computable languages and functions, techniques for turing machine construction, modification of turing machines, church's hypothesis, Turing machines as enumerators; Undecidability: properties of recursive and recursively enumerable languages, universal Turing machines, rice's theorem, post correspondence problem, greibach's theorem, introduction to recursive function theory, oracle computation; Chomsky Hierarchy: regular grammars, unrestricted grammars, context sensitive languages, relations between classes of languages.

Essential Reading:
1. Mishra & Chandrasekharan, *Theory of computer science: Automata language and computation*, Prentice Hall of India, 3rd Ed, 2007.
2. P. Linz, *Introduction to Formal Language and Computation*, Narosa, 2nd Ed, 2006.

Supplementary Reading:
1. Nasir & Sirmani, *A Text Book on Automata Theory*, Cambridge University Press, 2008.
2. H. R. Lewis & C. H. Papadimitriou, *Elements of the Theory of Computation*, Prentice Hall of India, 2nd Ed, 2006.

CS 332   ALGORITHM ANALYSIS AND DESIGN   4 credits [3-1-0]

Prerequisites: CS102

Abstract data structure as an organization of data with specified properties and operations Time and space analysis of algorithms Asymptotic Notation: Big Oh, Omega, Theta Notations, Average, best and worst case analysis Simple recurrence relations and use in algorithm analysis Analysis of Algorithms: Loops, Recursive Calls (Selection Sort, Insertion Sort, Euclid's Algorithm, Hanoi Towers), Solving Recurrences. ; Algorithmic strategies: Categorizing algorithms by methodology , Brute-force/exhaustive search algorithms, Greedy Algorithms,

Divide and Conquer Strategy, Dynamic Programming, Backtracking algorithm and Branch-Bound Algorithm. ; String Search problem: Naïve algorithm, Rabin-Karp scheme, FSA-based algorithm Knuth-Morris-Pratt algorithm ; Complexity theory: Decidability of problems: Halting problem, NP-class of problems, P-class problems, NP=P question, Polynomial problem reduction, Boolean satisfiability and Cook's theorem, NP-hardness and NP-completeness, NP-completeness FAQ including how to handle NP-hard problems, Examples of NP-completeness proofs: SAT to 3-SAT, 3-SAT to 3-D Matching, Reasoning with Cardinal algebra, Other models of computation: Art. Neural Net, Quantum Computing, DNA computing. Concept of lower bound theory & approximation algorithm.

Essential Reading:
1. E. Horowitz, S. Sahni and S. Rajasekaran, *Fundamentals of Computer Algorithms,* University Press, Indian reprint, 2008.
2. T. Cormen, C. Leiserson, and R. Rivest and C. Stain, *Introduction to Algorithms* Prentice Hall of India, 3rd Ed, 2006.

Supplementary Reading:
1. M. T. Goodrich and R. Tamassia, *Algorithm Design*, John Wiley & Sons, 1st Ed, 2002.
2. S. K. Basu, *Design methods and Analysis of Algorithms*, Prentice Hall of India, 1st Ed, 2005.

CS 333 OPERATING SYSTEMS 3 credits [3-0-0]

Prerequisites: NIL

Evolution of Operating Systems and Overview, Basic Concepts: Batch processing, Multiprogramming, Interrupts, Hardware concepts, Different types of OS, Goals, OS Structure, System calls. Process Management: Process, Concurrent Processes, Threads, Multithreading, Scheduling Algorithms, Inter-process Communication: Critical Section problem, Synchronization Mechanisms: software and hardware, semaphores, monitors, message passing, Classical IPC problems, Deadlocks: conditions, Deadlock Handling Strategies. Memory Management: Fixed & Variable, Paging, Segmentation, Virtual Memory: Demand paging, page replacement algorithms, Trashing, Strategies to control Trashing. File & Device Management: Files, Directory, File system Implementation, Example File systems, I/O hardware, I/O buffering, RAID. Security & Protection: Breaches, Solutions, mechanisms, Inside Attacks, outside attacks. Case study on UNIX.

Essential Reading:
1. J. L. Peterson & A. Silberschatz, *Operating System Concepts*, John Wiley & Sons, 7th Ed, 2008.
2. A. S. Tanenbum*, Modern Operating Systems*, Pearson, 3rd Ed, 2008.

Supplementary Reading:
1. Harris, *Schaum's Outline of Operating Systems*, Tata McGraw Hill, 11th Reprint, 2006
2. Stallings, *Operating Systems, Internals and Design Principles*, 5th Ed, PHI, 4th print, 2008
3. M. J. Bach, the *Design of the UNIX operating system*, Prentice Hall, reprint 2006.

CS 334   **OPERATING SYSTEMS DESIGN**   **3 credits [3-0-0]**

Prerequisites: CS 171/CS 172

Evolution of Operating Systems and Overview, Basic Concepts: Batch processing, Multiprogramming, Interrupts, Hardware concepts, Different types of OS, Goals, OS Structure, System calls. Process Management: Process, Concurrent Processes, Threads, Multithreading, Scheduling Algorithms, Queuing Models (M/M/1, M/M/K), Inter-process Communication: Critical Section problem, Synchronization Mechanisms: software and hardware, semaphores, monitors, message passing, Classical IPC problems, Deadlocks: conditions, Deadlock Handling Strategies. Memory Management: Fixed & Variable, Paging, Segmentation, Virtual Memory: Demand paging, page replacement algorithms, Trashing, Strategies to control Trashing. File & Device Management: Files, Directory, File system Implementation, Example File systems, I/O hardware, I/O buffering, RAID. Security & Protection: Breaches, Solutions, mechanisms, Inside Attacks, outside attacks. Concepts of Advanced OS: Distributed, Real Time, Multimedia, Multiprocessor, Network, Embedded, Database Operating Systems. Case studies – DOS, UNIX and Windows 2000. Basic OS Design Principles: Goals, Interface Design, Performance Considerations, Trends in Design.

Essential Readings:
1. J. L. Peterson & A. Silberschatz, *Operating System Concepts*, John Wiley & Sons, 7th Ed, 2008.
2. A. S. Tanenbum, *Modern Operating Systems*, Pearson, 3rd Ed, 2008.

Supplementary Readings:
1. Harris, *Schaum's Outline of Operating Systems*, Tata McGraw Hill, 11th Reprint, 2006.
2. Crowley, *Operating system, a Design-Oriented Approach*, Tata McGraw Hill, 2006.
3. M. J. Bach, The *Design of the UNIX operating system*, Prentice Hall, reprint 2006.
4. Stallings, Operating Systems, Internals and Design Principles, 5th Ed, PHI, 4th print, 2008.

CS 335   **COMPUTER GRAPHICS AND MULTIMEDIA**   **4 credits [3-1-0]**

Prerequisites: NIL

Introduction to Computer Graphics: Use of computer graphics, Elements of picture creation; Graphics Hardware: Display technologies, Graphics display devices, Graphics input primitives and devices; Two dimensional output primitives: Different forms of line equations, Points, Lines, Line drawing algorithms, Circle generating algorithms, Ellipse generating algorithm, Parallel algorithms, Filled area primitives; Two dimensional transformations: The geometries of transformations, Linear transformations, Translation, Rotation in plane, Rotation in space, Reflection, Homogeneous coordinates, Composite transformations; Polygons; Two dimensional viewing: Window to view port transformations, Line clipping, Polygon clipping; Three dimensional concepts: Display methods, Transformation, three dimensional viewing, Projections; Three dimensional shapes representations: Spline, Bezier curves and surfaces, Octrees, BSP trees, Fractal geometry; Halfspaces; Visible surface detection; Solid modeling; Shading; Advanced modeling techniques; Animation; Multimedia; Multimedia authoring tools; Graphics and image data representation; Color in Image & Video; Basics of Video and Audio; Compression; Content based retrieval.

Essential Reading:
1. D. Hearn and M. P. Baker, *Computer Graphics, C Version*, Pearson, 2nd Ed, 2003.
2. Ze-Nian Li, M. S. Drew, *Fundamentals of Multimedia,* Pearson, 1st Ed, 2004.

Supplementary Reading:
1. F. S. Hill, *Computer Graphics using Open GL*, Pearson, 2nd Ed, 2001.
2. R. Steinmetz, K. Nahrstedt, *Multimedia Systems*, Springer, 2004.
3. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, *Computer Graphics - Principles and Practice*, Second Edition in C, Addison Wesley, 2nd Ed, 2003.
4. D. F. Rogers, J. A. Adams, *Mathematical Elements for Computer Graphics,* McGraw Hill, 2nd Ed, 2001

CS 336   DIGITAL SIGNAL PROCESSING   4 credits [3-1-0]

Prerequisites: NIL

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

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

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

CS 338   SYSTEMS SOFTWARE   3 credits [3-0-0]

Prerequisites: CS 341

System Software and Machine Architecture, IBM 360 Instruction Set Architecture and Assembly language programs, The simplified Instructional Computer, traditional (CISC) Machine, RISC Machines; Language Processing; Assemblers, Cross assemblers, Macro processor, Single pass and multi pass, Linkers, Loaders, Relocating loaders and direct linking loaders, Compilers and Interpreters, Cross compilers, Lexical analyzer, Syntax analyzer, Intermediate and Machine code generation, Implementation Examples; Formal grammars and languages, Software Tools for program Development, Editors, Debug Monitors, Programming Environments, user Interface. Introduction to Operating Systems.

Essential Reading:
1. D.M. Dhamdhere, *Systems Programming and Operating Systems*, Tata McGraw Hill, 2nd Revised Ed, 2002.
2. J. J. Donovan, System Programming, Tata McGraw Hill, 2004.

Supplementary Reading:
1. M. J. Bach, The *Design of the UNIX operating system*, Prentice Hall, reprint 2006.
2. L. Beck, *System Software- An Introduction to Systems Programming*, Pearson, 1990

CS 341   MICROPROCESSORS AND MICROCONTROLLERS   4 credits [3-1-0]

Prerequisites: CS 243

Architecture of the 8086/8088 microprocessor, Internal operations, Maximum mode , Minimum mode of operation, Addressing modes, Instruction Format, Instruction execution timing, 8088 vs 8086; Assembly Language Programming: Data Transfer instruction, Arithmetic and Logical instructions, String Manipulation instructions etc needed for ALP, Modular programming: Simple assembler directives and operators, Linking and relocation, Stack, Procedures, Interrupt, Macro, Programming examples. Byte and string manipulation, I/O programming. 8087 Numeric data processor and its use in the 8086/8088 system, 8089 I/O processor (IOP), Architecture, Communication between CPU & IOP. Arithmetic Coprocessor, MMX and SIMD Technology; Bus interface, The 80386/80486/Pentium/Pentium II/Pentium III/Pentium IV Microprocessors; 8051 Microcontroller: Architecture, Instruction, Programming and Interfacing.

Essential Reading:
1. B. B. Brey, *The Intel Microprocessors 8086/8088, 80186/188, 80286, 80386, 80486 and Pentium and Pentium Pro Processors, Pentium 2,, Pentium 3 and Pentium 4: Architecture, Programming and Interface*, Prentice Hall of India, 7th ed, 2007.
2. M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 2nd Ed, 2006

Supplementary Reading:
1. Liu & Gibson, *Microcomputer Systems - The 8086/8088 Family Architecture, Programming and Design*, Prentice Hall of India, 2nd Ed, 2006.
2. D. V. Hall, *Microprocessor and Interfacing*, Tata McGraw Hill, 2nd Ed, 2006.

CS 343   DIGITAL LOGIC DESIGN   3 credits [3-0-0]

Prerequisites: NIL

History and overview, logic circuits, switching, memory, registers, digital systems, Boolean logic, sequential logic, gates, circuits, combinational circuits, Switching theory, number systems, binary arithmetic, switching algebra, minimization of switching functions, design of medium scale combinational logic module, multiplexers, demultiplexers, encoders, decoders, comparators, multipliers, dividers, ALUs, Hierarchical design, Memory elements: clocked and unclocked memory devices, master-slave devices, basic flip flops, timing constraints and propagation delays, data registers, RAM, Sequential logic : FSM, Mealy and Moore models, Synchronous sequential circuits, functional units, Digital System Design: Hierarchical, Modular, synthesis, design principles and techniques, functional units, controlling concepts, timing concepts, PLDs, FPGA, PLA, ROM, PAL, PLD. Modeling and simulation: schematic capture, schematic modeling, hardware description languages (VHDL, verilog), Functional simulation, simulation test bench design.

Essential Reading:
1. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with VHDL Design*, Tata McGraw Hill, 2005
2. A.B. Marcovitz, *Introduction to Logic Design*, Tata McGraw Hill, 2nd Ed, 2005.

Supplementary Reading:
1. R. P. Jain, *Modern Digital Electronics*, Tata McGraw Hill, 3rd ed, 2003.
2. S. C. Lee, *Digital Circuits & Logic Design*, Prentice Hall of India, 2001.

CS 371   DATA COMMUNICATION LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Study of serial and parallel communication.
2. Study of modem communication.
3. Study of wireless communication.
4. Principles of time division multiplexing.
5. Voice communication.
6. Principles of pulse code modulation techniques.
7. Bit synchronization and frame synchronization.
8. Principles of data reconditioning.
9. Amplitude shift keying modulation and demodulation techniques.
10. Delta modulation and demodulation.

CS 372   SYSTEMS ANALYSIS AND DESIGN LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

For Questions 1 – 10, do the followings:
  I. Prepare the SRS document. You have to identify the appropriate requirements for each problem.
 II. Draw the Context flow diagrams, level 1 and level 2 DFDs, using any CASE tool.
III. Draw the Structure charts, using any CASE tool.
 IV. Develop the corresponding software using C with a user friendly GUI and appropriate Database.
1. Develop a Library Information System for a technological University.
2. Develop a software for student registration in a technological University.
3. Develop a software for hall management of your Institute.
4. Develop a software for the Guesthouse automation of your Institute.
5. Develop a software for automating various bookkeeping activities of the student's cooperative store of your Institute.
6. Develop the Student's Academic Record Management Software of your Institute.
7. Develop a word processing software with some limited number of facilities such as making bold, italics, underline, cut, copy and paste etc.
8. Develop a graphics editor software package, using which one can create / modify several common types of graphics entities.
9. Develop a software for automating the various activities associated with developing a CASE tool for structured software analysis.
10. Develop a software for automating various activities of the department offices of your Institute.

CS 373   MICROPROCESSOR LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Design of a variable time delay counter (mod 8).
2. Measuring pulse width of a square wave.
3. Interfacing a stepper motor.
4. Interfacing a matrix keyboard (4×4).
5. Interfacing traffic light controller.
6. Implementing ADC.
7. Generating triangular saw tooth and square wave.
8. Communication between microprocessors using 8255PPI chip.
9. Generate various waveforms using DAC
10. Interfacing CRT to microprocessor.
11. Programming using 8086 kit.

CS 374   OPERATING SYSTEMS LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Process related assignments
- A parent process creates a child process that prints its PID.
- The child creates a grandchild and sleeps 120 seconds.
- The grandchild immediately exists.
- The parent sleeps for 60 seconds and then kills all the processes.
- message passing between child process and parent process using message queue
- message passing through pipes and shared memory

1. Simulation of CPU Scheduling Algorithms. (FCFS, RR, SJF, SPN, SRTF, HRRN, Priority, Multilevel Queuing)
2. Simulation of Dekker's, Petersons, Bakery Algorithms
3. Program to test the creation of 15-message queue starting at id-number 0-14.
4. Program to solve classical DINNING PHILOSPHER PROBLEM
5. Simulation of Banker's Algorithm for Deadlock Avoidance, Prevention
6. Simulation MVT and MFT with best fit, first fit, next fit and worst fit algorithms.
7. Program for FIFO, LRU, and OPTIMAL page replacement algorithm?
8. Simulate the following file organization techniques
9. (a) Single Level Directory;   (b) Two Level Directory; (c) Hierarchical (d) DAG
10. Basic Shell Script problems provided by Instructor on various shells of Unix

CS 375   COMPUTER GRAPHICS LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Basic shapes rasterisation.
2. Scan conversion of polygons
3. Polygon, Pattern filling
4. Understanding 2D transformation
5. Realizing various Projections
6. Representing curves and surfaces
7. Realizing parametric cubic curves and bicubic surfaces
8. Visible Surfaces Determination
9. Realizaition of illumination and shading
10. Basics of OpenGL

Thematically oriented project for the whole duration of the course for individual students or group of students

CS 376   DIGITAL SIGNAL PROCESSING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Representation of digital signal
2. Waveform generation
3. Convolution and Deconvolution
4. Correlation, Cross Correlation
5. Signal Transformation
6. Filter Design
7. Filter requirements and specification
8. Zero-Pole Analysis
9. Spectral Analysis
10. Case studies in DSP

CS 377   COMPUTATIONAL STATISTICS LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. **Data Structure:** Vector and matrix data manipulation. Data input/output. Data format. **Statistical graphics:** scatter plots, histograms, quantile-quantile (QQ) plot. visualizing bivariate data.
2. **Random numbers:** probability integral transform, how to generate random variables, vectors, matrices and stochastic processes.
3. **Matrix algebra:** Singular value decomposition, Cholesky factorization, Generalized inverse (Psudo inverse). least-squares estimation.
4. **Monte-Carlo methods:** Monte-Carlo integral, importance sampling, Monte-Carlo inference.
5. **Markov Chains**: random walks, transition probability. Chapman-Kolmogorov equation. invariant distributions.
6. **Markov chain monte carlo** (MCMC): Metropolis-Hastings algorithms. Gibbs sampler. Bayesian inference. Bayes estimates.

7. **Bootstrap methods:** Bootstraping techniques are introduced for estimation and inference problems.

Essential Reading:
1. Wendy L. Martinez and Angel R. Martinez , *Computational Statistics Handbook with MATLAB* Chapman & Hall/CRC, 2002

CS 378   SYSTEMS PROGRAMMING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Review of Instruction Set Architecture (8085, 8051 & IBM 360)
2. Fixed Point Arithmatic, Text Processing, Keyboard and Screen Processing, Disk processing, Copy-Protection Schemes, Implementation of a simple editor, adding syntax directed facilities to an editor
3. Implementation of Assembler
a) Single Pass
b) Two-pass
c) Multi-pass
4. implementation of Macro Processor
a) Single Pass
b) Integration with Assembler
5. Implementation of Loaders and Linkers
6. Implementation of Compiler
a) Lexical analyzer (Lex)
b) Parser (Yacc)
c) Intermediate code generation
d) Machine Code Generation

CS 379   NETWORK DESIGN AND SIMULATION LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Installation and configuration of NS2
2. Creating a network: nodes, links and queues
3. Creating connections, traffic and computing routers
4. Insertion of errors and analysis of trace file
5. Simple project on NS2 – wired, wireless and combination of wired and wireless
6. Implementation of new protocols in NS2

CS 384   ALGORITHM ANALYSIS AND DESIGN LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

Programming that uses recurrence relations to analyze recursive algorithms. Computing best, average, and worst case time complexity of various sorting techniques. Solving an optimization problem (TSP or 0-1 knap sack, or n-queen problem etc.) using different algorithmic strategies: Brute-force algorithms, Greedy algorithms, Divide-and-conquer, Backtracking, Branch-and-bound, Heuristics, Randomized algorithms, Dynamic programming. Performance analysis of different internal and external sorting algorithms with different type of data set. Use of divide and conquer technique to solve some problem that uses two different algorithm for solving small

problem. Implementation of different basic computing algorithms like Hash tables, including collision-avoidance strategies, Search trees (AVL and B-trees), Representations of graphs (adjacency list, adjacency matrix), Depth- and breadth-first traversals, Shortest-path algorithms (Dijkstra's and Floyd's algorithms), Transitive closure (Floyd's algorithm), Minimum spanning tree (Prim's , Solin's and Kruskal's algorithms), Topological sort, Pattern matching and string/text algorithms. Performance analysis of algorithms related to network Flow and matching problems Verification of lower bound of an algorithm, analyzing the performance of randomized algorithms for a specific problem; The laboratory work involves implementing various types of algorithms in C++, C (through the creation of header file) and Perl programming.

CS 412   SOFTWARE ENGINEERING   4 credits [3-1-0]

Prerequisites: CS312

Managing software projects Project management concepts, Software process and Project metrics, Software Project Planning, Risk Analysis and Management, Project scheduling and tracking, Software Quality Assurance, Software Configuration Management. Conventional methods for software engineering System Engineering, Analysis concepts and principles, Analysis Modeling, Design Concepts and principles, Architectural design, User Interface Design, Component level Design, Software Testing Techniques, Software testing Strategies, Technical metrics for software. Object oriented software engineering Object Oriented Concepts and principles, Object oriented analysis, object oriented Design, Object oriented testing, Technical metrics for object-oriented Systems**.**

Essential Reading:
1. R. S. Pressman, *Software Engineering A Practitioner's Approach*, Tata McGraw Hill, 6th Ed, 2005.
2. I. Sommerville, *Software Engineering*, Pearson, 7th Ed, 2005.

Supplementary Reading:
1. P. Jalote, *An Integrated Approach to Software Engineering*, Narosa, 2nd Ed, 1999.
2. A. Behferooz & F. J. Hudson, *Software Engineering Fundamentals*, Oxford Univ. Press, 1996.
3. R. Mall, *Fundamentals of Software Engineering*, Prentice Hall of India, 2nd Ed, 2006.

CS 413   ADVANCED PROGRAMMING SKILLS   3 credits [3-0-0]

Prerequisites: NIL

Different programming paradigms, Introduction to Java, Data types, Variables, Arrays, Operators, Control statements, Classes, Constructors, Destructors, Garbage collection, Overloading methods, Overloading Constructors, Argument passing, Returning objects, Recursion, Inheritance, Method overriding, Dynamic method dispatch, Abstract classes, Packages, Importing packages, Interfaces, Nested interfaces, Applying interfaces, Handling Exceptions, Java built-in exceptions, Introduction to multi-threaded programming, The java thread model, Synchronization, Messaging, The thread class and runnable interface, Creating a thread, Creating multiple threads, Enumertions, I/O basics, Applets, The HTML applets tag, Java library, Handling events, Introduction to AWT, The concurrency utilities, Java beans, Introduction to swings, Servelets. Introduction to C# , Basic concepts of .NET: the C# environment, Literals, Variables and data types, Operators and expressions, Control statements, Methods in C#, Arrays, Strings, Structures and Enumertions, Classes and objects,

Inheritance and polymorphism, Interfaces, Operator overloading, I/O basics, Handling Exceptions, multi-threading in C#, Windows and web based application development on .NET, Recent trends in programming methodologies.

Essential Reading:
1. H. Schildt, *The Complete Reference Java*, Tata Mc-Graw Hill, 7th Ed, 2006.
2. E. Balagurusamy, *Programming in C#: A Primer*, Mc-Graw Hill, 2nd Ed, 2008.

Supplementary Reading:
1. E. Balagurusamy, *Programming in JAVA*, Mc-Graw Hill, 3rd Ed, 2007.
2. J. M. Slack, *Programming and Problem Solving with JAVA*, Thomson/Brooks Core Publishing Company, 1st Indian Reprint, 2007.

**CS 414   SOFTWARE PROJECT, PROCESS AND QUALITY   4 credits [3-1-0]
             MANAGEMENT**

Prerequisites: CS 312

Introduction to S/W project management, S/W project management competencies, responsibilities of a software project manager, Software process, S/W process models, project planning, organization of project team, S/W size estimation, estimation of effort & duration, Halstead's software Science, models, dependency & scheduling, staffing, Organizing a software engineering project, S/W configuration management, monitoring & controlling S/W projects, developing requirements, risk management, project tracking & control, communication & negotiating, S/W quality, S/W quality engineering, defining quality requirements, quality standards, practices & conventions, ISO 9000, ISO 9001, S/W quality matrices, managerial and organization issues, defect prevention, reviews & audits, SEI capability maturity model, PSP, six sigma

Essential Reading:
1. B. Hughes, M. Cotterell, *Software Project Management*, McGraw Hill, 4th Ed, 2005.
2. R. Walker, *Software Project Management*, Pearson, 2003.

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

CS 416   BIOINFORMATICS   4 credits [3-1-0]

Pre-requisite: Knowledge on following is necessary:

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

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

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

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

CS 417   GRAPH THEORY AND NETWORK ALGORITHMS   3 credits [3-0-0]

Prerequisites: CS 326

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

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

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

CS 418   REAL TIME SYSTEMS   4 credits [3-1-0]

Prerequisites: CS334, CS341

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

Essential Reading:
1. P. A. Laplante, *Real-Time Systems Design & Analysis*, Willey, 3rd Ed, 2004.
2. R. Mall, *Real-Time Systems*, Pearson, 2007.

Supplementary Reading:
1. C. M. Krishna and K. G. Shin, *Real-Time Systems*, McGraw Hill, reprinted 2004.
2. J. W. S.Liu, *Real-time Systems,* Pearson Education, 6th impression, 2008.

CS 421   COMPUTER NETWORKS   3 credits [3-0-0]

Prerequisites: CS 326

Network fundamentals: protocols and standards; reference models; the significance of layered network architectures; connections and connectionless protocols, Physical links and interfaces: modems and modem standards; LAN characteristics and concepts; interconnection of LANs; WAN characteristics and concepts, Link layer aspects, synchronous and asynchronous transmission; Framing, Error detection and correction, Sliding window protocols; MAC Layer; network layer aspects, addressing, connection vs connectionless, Routing Algorithms, internetworking; transport layer aspects, reliable transport connections, Internet Protocol (IP); naming and addressing; routing; the Transmission Control Protocol (TCP); application and management protocols, Exploring Internet services: the dial-in end-user; the direct connection user; the Internet Service Provider; the global Internet, Emerging technologies over the Internet, such as IPv6 and ATM for a multimedia network; Internet Telephone;

Essential Reading:
1. B. Forouzan, *Data Communications and Networking*, Tata McGraw Hill, 4th Ed, 2007.
2. A. S. Tanenbaum, *Computer Networks*, Prentice Hall of India, 4th Ed, 2006.

Supplementary Reading:
1. F. Halsall, *Data Communication, Computer Networks and Open Systems*, Addison Wesley, 4th Ed.
2. W. Stallings, *Data and Computer Communications*, Prentice Hall of India, 7th Ed, 2006.
3. A. Leon-Garcia & I Widjaja, *Communication Networks, Fundamental Concepts & key Architecture*, Tata McGraw Hill, 2nd Ed, 2003.

CS 423   AD-HOC AND WIRELESS NETWORKS   4 credits [3-1-0]

Prerequisites: CS 421

Ad Hoc Wireless Networks: Issues in Ad Hoc Wireless Networks, Ad Hoc Wireless Internet; MAC Protocols for Ad Hoc Wireless Networks: Issues in Designing a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols; Routing Protocols for Ad Hoc Wireless Networks: Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Power-Aware Routing Protocols; Multi-cast routing in Ad Hoc Wireless Networks: Issues in Designing a Multicast Routing Protocol, Classifications of Multicast Routing Protocols, Energy-Efficient Multicasting, Multicasting with Quality of Service Guarantees, Application-Dependent Multicast Routing; Security Protocols for Ad Hoc Wireless Networks: Security in Ad Hoc Wireless Networks. Network Security Requirements. Issues and Challenges in Security Provisioning. Network Security Attacks. Key Management. Secure Routing in Ad Hoc Wireless Networks; Energy Management in Ad Hoc Wireless Networks: Classification of Energy Management Schemes, Transmission Power Management Schemes, System Power Management Schemes.

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

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

CS 425   DATA MINING AND DATA WAREHOUSING   4 credits [3-1-0]

Prerequisites: CS 222

Introduction to Data mining: Motivation for Data Mining, its importance, Role Data in Data Mining, Data Mining functionalities, patterns in data mining, Type of patterns, Classification of Data Mining Systems, Major issues in Data Mining; Data Warehousing and OLTP technology for Data Mining, Data Mining Languages, and System Architectures, Concept Description: Characterization and Comparison, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis, Mining Complex Data, Applications and Trends in Data Mining Characteristics of data warehouse, Data Mart, Online Analytical Processing, OLAP tools, Data warehouse Architecture, Organizational Issuer, Tools for Data warehousing, Performance consideration, case studies.

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

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

CS 427   NETWORK SECURITY   4 credits [3-1-0]

Prerequisites: CS 325

Key exchange protocols. Diffie-hellman and its variants, Man in the middle attack. PKI and certificate based key exchange. Key management. Protocol weakness in TCP/IP and other protocols. Various types of attacks. Security protocol at application level: PGP, SHTTP, SSH etc. Security protocol at socket level: SS/TSL. Security protocol at network level: IPSec. Security protocol for remote connections through dial-up etc: PPTP, L2TP. Firewall and packet filtering. Proxy or application level gateways as security devices. Virtual private networks, Intrusion detection system. Privacy protection and anonymity services. Electronic payment system.

Essential Reading:
1. W. Stalling, *Cryptography and Network Security: Principles and Practices*, 4th Ed, PHI, 2007.
2. B. A. Forouzan, *Cryptography and Network Security,* McGraw Hill, 1st Ed.

Supplementary Reading:
1. J. M. Kizza, *Computer Network Security*, Springer, 2005.
2. Peterson and Davie, *Computer Networks A System Approach*, Elsevier, 3rd Ed.

CS 430   INFORMATION THEORY AND CODING   4 credits [3-1-0]

Prerequisites: NIL

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

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

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

CS 431   COMPILER DESIGN   3 credits [3-0-0]

Prerequisites: CS 331 & CS 338

Introduction: Introduction and overview of the compilation process, Model of a compiler, translators, interpreters, assemblers, languages, Types of compilers, assemblers, interpreters and compilers. Compilation of simple expressions and statements, Organization of a compiler, compiler design tools, bootstrapping, compiler, Computer architecture vs. compiler design; **Context-Free Grammar and Syntax Analysis:** Syntax analysis, Parsing: Top-Down and Bottom Up parsing, general parsing strategies. Brute-force approach, recursive descent parser and algorithms, simple LL(1) grammar, LL(1) with null and without null rules grammars, Bottom-up parsing- Handle of a right sentential form, Shift-reduce parsers, operator precedence parsing , LR, SLR, canonical LR and LALR grammar and parsers; **Symbol-Table contents, organization and Management; Syntax –Directed Definitions and Translations**: syntax-directed translation schemes, intermediates code generation, translation schemes for programming language constructs; **Code Optimization, Code Generation, Error Handling.**

Essential Reading:
1. A. V. Aho, Ravi Sethi & Jeffrey D. Ullman, *Compilers: Principles, Techniques, and Tools*, Pearson Education, 1st Ed, 2008.
2. K. C. Louden, *Compiler Construction Principles and Practice*, Thomson Learning Inc. 1st Ed, 2007.

Supplementary Reading:
1. A. W. Apple, *Modern compiler implementation in C*, Cambridge University Press, 1st Ed, 2003.
2. W. A. Barrett, John D. Couch, C. Couch, C*ompiler Construction: Theory and Practice*, Science Research Associates, 1979.
3. K. C. Louden, *Compiler Construction: Principle and practice*, Galgotia, 1997.

CS 432   DISTRIBUTED OPERATING SYSTEMS   4 credits [3-1-0]

Prerequisites: CS334, CS421

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

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

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

CS 433   ALGORITHM DESIGN   3 credits [3-0-0]

Prerequisites: NIL

History and overview: Identifying some contribution to algorithms and relate their achievements to the knowledge area. Associate some of the themes involved with algorithms, Name some applications where algorithms are important, Describe how computer engineering users or benefits from algorithm; Basic algorithm analysis: Asymptotic analysis of upper bound and average complexity bounds, Identifying difference among average, best and worst case behaviors, Big 'O', little 'o' omega, and theta notation, Empirical measurement of performance, Time and space tradeoffs in algorithms, Using recurrence relations to analyze recursive algorithm. Problem, problem representation, solution space, solution through best algorithm, methods of algorithm design and analysis. The relationship of algorithms to data structures; Algorithmic strategies: Categorizing algorithms by methodology, Brute-force/exhaustive search algorithms, Greedy Algorithms, Divide and Conquer Strategy, Dynamic Programming, Backtracking algorithm and Branch-Bound Algorithm; Computing Algorithms: Simple numerical algorithms, sequential and binary search algorithms, sorting algorithms, Hash Table, including collision avoidance strategies, Binary search Trees, Representation of Graphs, Depth and Breadth first traversal, shortest path algorithms(Dijkstra and Floyd's algorithm) Transitive closure (Floyd's algorithm), Minimum spanning tree(Prim's and Kruskal algorithm); Algorithmic complexity: Tractable and intractable problems, definition of the class P and NP, NP completeness (Cook's theorem), Standard Np-complete problems, Uncomputable functions, The halting problem, Implications of Uncomputability, Coping with intractability.

Essential Reading:
1. E. Horowitz, S. Sahni and S. Rajasekaran, *Fundamentals of Computer Algorithms,* University Press, Indian reprint, 2008.
2. T. Cormen, C. Leiserson, and R. Rivest and C. Stain, *Introduction to Algorithms* Prentice Hall of India, 3rd Ed, 2006.

Supplementary Reading:
1. M. Weiss, Data Structures and Algorithm Analysis in C++, Pearson, 4th Ed, 2008.
2. S. K. Basu, *Design methods and Analysis of Algorithms*, Prentice Hall of India, 1st Ed, 2005.

CS 434   IMAGE PROCESSING   4 credits [3-1-0]

Prerequisites: NIL

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

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

Supplementary Reading:
1. W. K. Pratt, *Digital Image Processing,* Wiley-Interscience, 4th Ed, 2007.
2. A. Rosenfled & A. C. Kak, Vol.I, *Digital Picture Processing*, Academic Press, 1976.

CS 435   ARTIFICIAL INTELLIGENCE   3 credits [3-0-0]

Prerequisites: NIL

Basic concepts of AI; Problems in AI; Applications; Production systems; Problem solving methods; Forward vs backward reasoning; Search in state spaces, state-space graph, uninformed search, heuristic search, general graph search algorithms, 2-agent games; knowledge representation using predicate calculus; rules of inference; converting arbitrary wff to conjunction of clauses, resolution reputation system; Answer extraction; Intro to expert system.

Essential Reading:
1. E. Rich and K. Knight, *Artificial Intelligence*, Tata McGraw Hill, 2nd Ed, 1991.
2. N. J. Nilsson, *Principles of Artificial Intelligence*, Narosa, 1986.

Supplementary Reading:
1. S. Russel and P. Norvig, *Artificial Intelligence: a modern Approach*, Pearson, 2nd Ed, 2003.
2. D. W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, Prentice Hall of India, 2006.

CS 437   SOFT COMPUTING   3 credits [3-0-0]

Prerequisites: NIL

Introduction to Neorofuzzy and Soft Computing, Fuzzy set theory, Fuzzy Rules, Fuzzy Reasoning, Fuzzy inference System, Neural Networks; Radial basis and recurrent neural networks, Hopfield Networks, Comparision of RBF and MLP Network, Running Algorithms, NeuroFuzzy Modeling, Applications of Soft Computing to Signal Processing, Image Processing, Forecasting, XOR Problem-traveling salesman problem, Image compression suing MLPs-character retrieval using hopfield networks, Introduction to Genetic Algorithm hybrid Systemsetc.

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

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

CS 438   PATTERN RECOGNITION   4 credits [3-1-0]

Prerequisites: CS 102

Introduction to pattern recognition, statistical pattern recognition, decision trees, classification using decision trees, obtaining Prules from decision trees, missing attribute values, error rates on recall sets, pruning decision trees, obtaining Prules by evolution, Bayes classification, estimation of probabilities, nearest neighbor classification, performance issues of a nearest neighbor classifier, Neural classifier, training of neural classifier, clustering, Agglomerative hierarchical clustering, K-means clustering, syntactic pattern recognition.

Essential Reading:
1. R. Shighal, *Pattern Recognition: Techniques and Applications*, Oxford University Press, 1st Ed, 2006.
2. Christopher M. Bishop, *Neural Networks for Pattern Recognition,* Oxford University Press, 1st Ed, 2003.

Supplementary Reading:
1. William Gibson, *Pattern Recognition*, Berkley Press, 1st Ed, 2005.
2. Christopher M. Bishop, *Pattern Recognition and Machine Learning,* Springer, 1st Ed, 2007.

CS 439   COMPUTER VISION   3 credits [3-0-0]

Prerequisites: NIL

Image Formation and Image Models: Cameras; Radiometry – Measuring Light; Shadows and Shading; Color representation; Linear filters; Edge Detection; Pyramids and Textures; Multiple view geometry; Stereo; Optical flow; Affine structure from motion; Projective structure from motion; Calibration; Segmentation; Fitting; Linear Tracking; Non-Linear Tracking; Template Matching; Object Recognition; Case study of various applications.

Essential Reading:
1. D. A. Forsyth, J. Ponce, *Computer Vision – A Modern Approach*, Pearson, 2005.
2. L. G. Shapiro, G. C. Stockman, *Computer Vision*, Prentice Hall, 2001.

Supplementary Reading:
1. B. Jähne, H. Haußecker, *Computer Vision and Applications – A Guide for Students and Practitioners,* Academic Press, 2000.
2. R. J. Schalkoff, *Digital Image Processing and Computer-Vision*, John Wiley and Sons, 1989.

CS 441   ADVANCED COMPUTER ARCHITECTURE   4 credits [3-1-0]

Prerequisites: CS 242, CS 341

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

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

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

CS 442   COMPUTER SYSTEM ARCHITECTURE   3 credits [3-0-0]

Prerequisites: NIL

Organization of a computer, Von-Neumann stored computer architecture, Processor Organization: Information representation, Number formats, Instruction format; execution cycle, Instruction sets: Addressing modes and Formats, Fixed point arithmetic, ALU design, CPU structure and functions, Reduced Instruction set Computer: CISC Characteristics, RISC characteristics. Memory Organization: Memory technology: Memory device technology, Random access memory Virtual Memory, High speed Memory, Internal memory: semiconductor main memory, cache memory, Advanced DRAM organization, External memory, magnetic disk, RAID, Optical memory, magnetic tape. I/O organization: Bus control, Serial I/O (study of Asynchronous and synchronous modes, USART & VART), Parallel Data transfer: (Program controlled: Asynchronous, synchronous & Interrupt driven modes, DMA mode, interrupt controller and DMA controller).

Essential Reading:
1. V. Carl Hamacher, Z. G. Veranesic, and S. G. Zaky, *Computer Organisation*, Tata Mc-Graw Hill, 5th Ed, 2002.
2. William Stallings, *Computer Organization and Architecture Design for Performance*, Prentice Hall of India, 7th Ed, 2006.

Supplementary Reading:
1. M. Morris Mano, *Computer System Architecture*, Prentice Hall of India, 1982.
2. J. P. Hayes, *Computer Architecture and Organisation*, Mc-Graw Hill, 3rd Ed, 2006.
3. D. A. Pattersen and J. L. Hennesy, *Computer Organisation and Design: The Hardware Software Interface*, Elsevier, 2nd Ed.

CS 443   EMBEDDED SYSTEMS   4 credits [3-1-0]

Prerequisites: CS 334, CS 341, CS 242, CS 243

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

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

Supplementary Reading:
1. S. V. Iyer & P. Gupat, *Embedded Real Time System Programming*, Tata McGraw Hill, 2004.
2. W. Wolf, *Computer as Components: Principles of Embedded Computer System Design*, Elsevier, 2005
3. S. Heath, *Embedded System Design*, 2nd Ed, Elsevier, 2005.
4. R. Mall, *Real Time Systems Theory and Practice*, Pearson, 2008
5. F. Vahid & T. Givargis, *Embedded Ssytem design: A unified Hardware/Software approach*, Wiley, 2007
6. G. D. Michelli & L. Benin, *Network-on-Chip*, Morgan & Kaufman Publication, 2004.

CS 444   CLUSTER AND GRID COMPUTING   4 credits [3-1-0]

Prerequisites: CS 334, CS 421

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

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

Supplementary Reading:
1. Pankaj Jalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994.
2. J. J. Jos & R. K. Buyya, High Performance Cluster Computing: Architectures and Systems, Vol I, Prentice Hall, NJ, USA, 1999.
3. R. K. Buyya & C. Szyperski, *Cluster Computing*, Nova Science, New York, USA, 2001.
4. R. K. Buyya & K. Bubendorfer, *Market Oriented Grid and Utility Computing*, Wiley, 2008.
5. J. Jaseph & C. Fellenstein, *Grid Computing*, Pearson, 1st Ed, 2004.

CS 445   PARALLEL ALGORITHMS   4 credits [3-1-0]

Prerequisites: CS 242

Modeling; Synchronous Network Model, Leader Election in a Synchronous Ring, Algorithms in General Synchronous Networks, Distributed Consensus with Link Failures, Distributed Consensus with Process Failures, More Consensus Problems, Asynchronous System Model, Asynchronous Shared Memory model, Mutual Exclusion, Resource Allocation, Consensus, Atomic Objects, Asynchronous Network Model, Basic Asynchronous Network Algorithms, Synchronizers, Shared Memory versus Networks, Logical Time Global Snapshots and stable properties, Network Resource allocation, Asynchronous Networks with Process Failures, Data Link Protocols, Partially Synchronous Models, Mutual Exclusion with Partial Synchrony, Consensus with Partial Synchrony.

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

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

CS 449   VLSI SYSTEM DESIGN   4 credits [3-1-0]

Prerequisites: CS 243, CS 331

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

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

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

CS 471   NETWORK LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Study of network simulator NetSim ver 2.0.
2. Simulation study of pure ALOHA protocol.
3. Simulation study of slotted ALOHA protocol.
4. Simulation study of Token Bus LAN protocol.
5. Simulation study of Token Ring LAN protocol.
6. Simulation study of WAN protocol like Frame Relay, X.25.
7. Implementation of shortest path routing algorithm.
8. Study of 802.11 wireless LAN protocols.

CS 472   SOFTWARE ENGINEERING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

For Questions 1 – 8, do the followings:
  (a) Prepare the SRS document. You should identify the appropriate requirements for each problem.
  (b) Draw the Use Case diagrams, Domain Models, and Class Diagrams using Rational Rose.
  (c) Draw the Sequence Diagrams and Collaboration Diagrams for each Use Case, using Rational Rose.
  (d) Draw the State Chart Diagrams and Activity Diagrams using Rational Rose, wherever necessary.
  (e) Develop the corresponding software using Java with an interactive GUI and appropriate Database.

1. Develop software to automate the bookkeeping activities of a 5-star hotel.
2. The local newspaper and magazine delivery agency wants to automate the various clerical activities associated with its business. Develop a software for this.
3. A small automobile spare parts shop sells the spare parts for vehicles of several makes and models. Each spare part is typically manufactured by several small industries. To streamline the sales and supply ordering, the shop owner wants to automate the activities associated with his business.   Develop a software for this.
4. Develop a software for the automation of the dispensary of your Institute.
5. Develop a software for automating various activities of an Estate Office.
6. Develop a word processing software with some limited number of facilities such as making bold, italics, underline, cut, copy and paste etc.
7. Develop a graphics editor software package, using which one can create/modify several common types of graphics entities.
8. Develop a software for automating various activities of the department offices of your Institute.
9. Write a C function for searching an integer value from a large sorted sequence of integer values stored in array of size 100, using the binary search method. Build the control flow graph of this function using any compiler-writing tool. Write a program in Java to determine its cyclomatic complexity.
10. Write a program in Java to determine the number of defects still remaining after testing, using error seeding methodology.

CS 473   REAL TIME SYSTEMS LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

Installation of RT Linux on Linux, Simulation of various scheduling algorithms such as Table driven scheduling, Cyclic scheduling, EDF scheduling, RMA etc., Comparison of the relative performances such as response time etc. of the schedulers, Develop a watch dog timer, Comparing the features of various real time operating systems such as RT POSIX, PSOS, VRTX, Vx Works, QNX, C/OS-II, Lynx, Windows CE etc., Development of a real time database.

CS 474   IMAGE PROCESSING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Understanding the image formation
2. Exercise on image transformations
3. Assignments on image enhancement by point processing
4. Image enhancement in frequency domain
5. Understanding the concept of image degradation
6. Realizing different approaches of restoration
7. Implementation of different image compression techniques
8. Detection of discontinuity, edge linking, boundary detection
9. Region oriented segmentation
10. Thematically oriented project for the entire duration of the course for individual students or group of students. Laboratory works are to be done in C or MatLab.

CS 477   SOFT COMPUTING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Implementation of selected soft-computing methods presented during the lecture.
2. Implementation of various learning strategies
3. Realization of MLP, RBF, Hopfield networks etc
4. Solving optimization problems
5. Understanding and realizing Fuzzy Logic and Fuzzy inference
6. Programming Genetic Algorithms.
7. Understanding probabilistic reasoning, rough sets, chaos.
8. Realization of hybrid approaches

CS 478   PARALLEL COMPUTING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Study of MPI and PVM
2. Inter-process Communication using UNIX/LINUX, Critical Section simulation
3. Readers/Writers Simulation, Producers/Consumers Simulation, Implementation of semaphores
4. Parallel Quicksort, Matrix Multiplication using Processes
5. Finding Patterns in a set of files, Multithread Programming
6. Parallel Algorithm for Array processors, Parallel Image Processing Applications
7. Processor virtualization using MPI implementation,
8. Programming under Cluster and Grid environments

CS 479   ADVANCED LINUX PROGRAMMING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

Editing with Emacs, Compiling with GCC , Automating the Process with GNU Make, Debugging with GNU Debugger(GDB). Processes: Creating Processes, Signals, Process Termination. Threads: Thread Creation , Thread Cancellation , Thread-Specific Data, Synchronization and Critical Sections, GNU/Linux Thread Implementation .Interprocess Communication: Shared Memory, Processes Semaphores, Mapped Memory, Pipes, Sockets. Devices: Device Types & Numbers, Device Entries, Hardware Devices & Special Devices, PTYs, and *ioctl* . The /proc File System: Extracting Information from */proc,* Process Entries, Hardware Information, Kernel Information, Drives, Mounts, and File Systems, System Statistics. Linux System Calls: Using *strace, access*:Testing File Permissions, *fcntl*: Locks and Other File Operations , *fsync* and *fdatasync*: Flushing Disk Buffers, *getrlimit* and *setrlimit*: Resource Limits, *getrusage*: Process Statistics, *gettimeofday*:Wall-Clock Time, The *mlock* Family: Locking Physical Memory , *mprotect*: Setting Memory Permissions, *nanosleep*: High-Precision Sleeping, *readlink*: Reading Symbolic Links, *sendfile*: Fast Data Transfers, *setitimer*: Setting Interval Timers, *sysinfo*: Obtaining System Statistics, *uname etc..*

CS 481   COMPILER DESIGN LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

Programming with different compiler writing tools like lex and yacc, **or Flex and Bison** for object and non object oriented language. Understanding to the file structure, the tokens in which data is to be parsed , the tree in which parsed data is to be stored with lex and yacc. Compiling & running simple programs for specific problems (thermostat controller, finding the header files required for specific function used by programmers in program, designing a desk calculator, Implement an alternative grammars for infix expressions, Write a grammar for complete s-expressions; Programs relating to code generation, and register allocation: program to generate code for a specific assembler, program to identify specific control structures, inserting comments, identifying specific blocks for code partitioning. Build a lexical analyzer and a syntactic analyzer for EBNF(Students are encouraged to use some thing different like ANTLR and JAVACC); writing a simple HTML-to-TXT translator that reads from standard input text file and writes to standard output and write program that involves embellishing the parser so that it enforces some simple grammatical rules; Introduction to an Object Oriented version of YACC, Concepts to learn multiple instances of same parser which can be used concurrently or in

parallel. Designing an **XML Parser,** Converting Lexacy Data to XML using a Lexer/Parser Generator, Using a Lexer/Parser Generator as a Multipurpose XML Tool Builder.

CS 482   DISTRIBUTED COMPUTING LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Familiarization with JAVA, C++, MPISIM, PVM
2. Client-Server Chart, TCP Simple Message Transfer
3. DNS using UDP, File Transfer using FTP
4. File Transfer using RS-232C
5. Implementation of RPC
6. Remote file reading using Sockets, Client and Server Classes
7. Remote data base using remote method invocation (RMI), Interface, Client and Server
8. Programming Clusters and Grids
9. Familiarization with Web Programming and Globus Tool Kits

CS 485   ARIFICIAL INTELLIGENCE LABORATORY   2 credits [0-0-3]

Prerequisites: NIL

1. Write a program to solve Traveling Salesman problem. The heuristic function used, number of nodes generated, depth of the search at each stages should be given in the form of a table.
2. Write a program to solve 8 puzzle problem with different heuristics
3. Implement the alpha – beta search procedures. Use it to play the game tic-tac-toe. At the end of the game your program should give the number of nodes generated, cut-off values at each stages in the form of a table
4. Write an ATN interpreter. Minimize the amount of information that must be stored at each node to allow back-up
5. Write an Eliza like program to converse in some domain. The program should consist of two parts, a database of rules and the code that matches rules against the input and uses them to generate output. The left side of each rule should be a pattern that can be matched against a sentence input by the user. The right side should specify the response that the system will generate if the corresponding left side matches
6. Develop an knowledge base system consisting of facts and rules about some specialized knowledge domain of your choice.
7. Implement Unification Algorithms. Input data sets may be any Well Formed Formulas.
8. Write a program to schedule a meeting between five busy people using default reasoning. The output should give the time, place and day of the meeting.

CS 489   **COMPUTER VISION LABORATORY**   **2 credits [0-0-3]**

Prerequisites: NIL

1. Fitting a Curve, Plane, Conic Section;
2. Implementation of linear and non-linear calibration algorithm
3. Surface Rendering, Shadow and Illumination
4. Implementation of Stereo Systems
5. Color constancy algorithm
6. Realization of different filters, implementation edge detection algorithms
7. Implementation of different approaches to stereopsis
8. Understanding Affine structure from motion
9. Segment based clustering
10. Object recognition

Individual student would be assigned a project work to be executed during the tenure of the course. C, MatLab, OpenGL softwares are to be used for this laboratory works.