# Syllabus for B.Tech. (COMPUTER SCIENCE & ENGINEERING) 2014 onward

| First Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course No.** | **Course Name** | **L** | **T** | **P** | **C** | | **Course No.** | **Course Name** | **L** | **T** | **P** | **C** |
| **Semester – 1 Group I** | | | | | | | **Semester – 1 Group II** | | | | | |
| CH101 | Chemistry | 3 | 0 | 0 | 6 | | CS101 | Introduction to Computing | 3 | 0 | 0 | 6 |
| ME101 | Engineering Mechanics | 3 | 1 | 0 | 8 | | EE101 | Basic Electrical & Electronics Sciences | 3 | 1 | 0 | 8 |
| MA101 | Mathematics - I | 3 | 0 | 0 | 6 | | MA101 | Mathematics - I | 3 | 0 | 0 | 6 |
| PH101 | Physics - I | 3 | 0 | 0 | 6 | | PH101 | Physics - I | 3 | 0 | 0 | 6 |
| HS101 | Communication Skills | 2 | 0 | 0 | 4 | | CE101 | Environmental Studies | 2 | 0 | 0 | 4 |
| CH111 | Chemistry Laboratory | 0 | 0 | 2 | 2 | | CS111 | Computing Laboratory | 0 | 0 | 4 | 4 |
| ME111/PH111 | Workshop/Physics Laboratory | 0 | 0 | 3 | 3 | | PH111/ME111 | Physics Laboratory/Workshop | 0 | 0 | 3 | 3 |
| ME112 | Engineering Drawing | 1 | 0 | 3 | 5 | | EE111 | Basic Electrical & Electronics Sciences laboratory | 0 | 0 | 3 | 3 |
| SA101 | NCC/NSS/NSO1 | 0 | 0 | 2 | 0 | | SA 101 | NCC/NSS/NSO1 | 0 | 0 | 2 | 0 |
| | | **15** | **1** | **10** | **40** | | | | **14** | **1** | **12** | **40** |

| First Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course No.** | **Course Name** | **L** | **T** | **P** | **C** | | **Course No.** | **Course Name** | **L** | **T** | **P** | **C** |
| **Semester – II Group II** | | | | | | | **Semester – II Group I** | | | | | |
| CH101 | Chemistry | 3 | 0 | 0 | 6 | | CS101 | Introduction to Computing | 3 | 0 | 0 | 6 |
| ME101 | Engineering Mechanics | 3 | 1 | 0 | 8 | | EE101 | Basic Electrical & Electronics Sciences | 3 | 1 | 0 | 8 |
| MA102 | Mathematics - II | 3 | 0 | 0 | 6 | | MA102 | Mathematics - II | 3 | 0 | 0 | 6 |
| PH102 | Physics - II | 3 | 0 | 0 | 6 | | PH102 | Physics - II | 3 | 0 | 0 | 6 |
| HS101 | Communication Skills | 2 | 0 | 0 | 4 | | CE101 | Environmental Studies | 2 | 0 | 0 | 4 |
| CH111 | Chemistry Laboratory | 0 | 0 | 2 | 2 | | CS111 | Computing Laboratory | 0 | 0 | 4 | 4 |
| ME111/PH111 | Workshop/Physics Laboratory | 0 | 0 | 3 | 3 | | PH111/ME111 | Physics Laboratory/Workshop | 0 | 0 | 3 | 3 |
| ME112 | Engineering Drawing | 1 | 0 | 3 | 5 | | EE111 | Basic Electrical & Electronics Sciences Laboratory | 0 | 0 | 3 | 3 |
| SA102 | NCC/NSS/NSO II | 0 | 0 | 2 | 0 | | SA102 | NCC/NSS/NSO II | 0 | 0 | 2 | 0 |
| | | **15** | **1** | **10** | **40** | | | | **13** | **1** | **12** | **40** |

# Syllabus for B.Tech. (COMPUTER SCIENCE & ENGINEERING) 2014 onward

**Second Year**

| Course No. | Course Name | L | T | P | C | | Course No. | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester – 3** | | | | | | | **Semester – 4** | | | | | |
| MA201 | Mathematics III | 3 | 0 | 0 | 6 | | CS202 | Formal Languages and Automata Theory | 3 | 1 | 0 | 8 |
| CS201 | Data Structures | 3 | 0 | 0 | 6 | | CS204 | Algorithms | 3 | 0 | 0 | 6 |
| CS203 | Discrete Mathematics | 3 | 1 | 0 | 8 | | CS206 | Computer Organization and Architecture | 3 | 0 | 0 | 6 |
| CS205 | Digital Design | 3 | 0 | 0 | 6 | | CS208 | Object Oriented Programming | 3 | 0 | 0 | 6 |
| HS201 | Engineering Economics & Accountancy | 2 | 0 | 0 | 4 | | MA202 | Probability and Random Processes | 3 | 0 | 0 | 6 |
| CS231 | Data Structures Lab | 0 | 0 | 3 | 3 | | CS232 | Algorithms Lab | 0 | 0 | 3 | 3 |
| CS233 | Digital Design Lab | 0 | 0 | 3 | 3 | | CS234 | Object Oriented Programming Lab | 0 | 0 | 3 | 3 |
| SA201 | NCC/NSO/COS | 0 | 0 | 2 | 0 | | CS236 | Peripherals and Accessories Lab | 0 | 0 | 3 | 3 |
| | | | | | | | SA202 | NCC/NSO/COS | 0 | 0 | 2 | 0 |
| | | **14** | **1** | **8** | **36** | | | | **15** | **1** | **11** | **41** |

**Third Year**

| Course No. | Course Name | L | T | P | C | | Course No. | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester – 5** | | | | | | | **Semester – 6** | | | | | |
| MA301 | Optimization | 3 | 0 | 0 | 6 | | HS302 | Management and Managerial Economics | 2 | 0 | 0 | 4 |
| CS301 | Software Engineering | 3 | 0 | 0 | 6 | | CS302 | Databases | 3 | 0 | 0 | 6 |
| CS303 | Operating Systems | 3 | 0 | 0 | 6 | | CS304 | Compilers | 3 | 0 | 0 | 6 |
| CS305 | Data Communication | 3 | 1 | 0 | 8 | | CS306 | Computer Networks | 3 | 0 | 0 | 6 |
| CS307 | Machine Learning | 3 | 0 | 0 | 6 | | CS308 | Information Storage and Retrieval | 3 | 1 | 0 | 8 |
| CS331 | Software Engineering and System Software Lab | 0 | 0 | 3 | 3 | | CS332 | Databases Lab | 0 | 0 | 3 | 3 |
| CS333 | Operating Systems Lab | 0 | 0 | 3 | 3 | | CS334 | Compilers and System Programming Lab | 0 | 0 | 3 | 3 |
| CS335 | Machine Learning Lab | 0 | 0 | 3 | 3 | | CS336 | Computer Networks Lab | 0 | 0 | 3 | 3 |
| | | | | | | | | | | | | |
| | | **15** | **1** | **9** | **41** | | | | **14** | **1** | **9** | **39** |

| Final Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course No.** | **Course Name** | **L** | **T** | **P** | **C** | | **Course No.** | **Course Name** | **L** | **T** | **P** | **C** |
| **Semester – 7** | | | | | | | **Semester – 8** | | | | | |
| CS401 | Computer Graphics | 3 | 0 | 0 | 6 | | CS4XX | Department Elective - IV | 3 | 0 | 0 | 6 |
| MA203 | Numerical Methods | 3 | 0 | 0 | 6 | | CS4XX | Department Elective - V | 3 | 0 | 0 | 6 |
| CS4XX | Department Elective - I | 3 | 0 | 0 | 6 | | CS4XX | Department Elective - VI | 3 | 0 | 0 | 6 |
| CS4XX | Department Elective - II | 3 | 0 | 0 | 6 | | CS482 | Project - II | 0 | 0 | 9 | 9 |
| CS4XX | Department Elective - III | 3 | 0 | 0 | 6 | | | | | | | |
| CS471 | Computer Graphics Lab | 0 | 0 | 3 | 3 | | | | | | | |
| CS473 | Project - I | 0 | 0 | 6 | 6 | | | | | | | |
| | | **15** | **0** | **9** | **39** | | | | **9** | **0** | **9** | **27** |

Total Credits: **303**

| **CS201** | **DATA STRUCTURES** | **3-0-0-6** |
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*Syllabus :* Performance of algorithms: space and time complexity, asymptotics; Fundamental Data structures: linked lists, arrays, matrices, stacks, queues, binary trees, tree traversals; Algorithms for sorting and searching: linear search, binary search, insertion-sort, selection sort, bubble-sort, quicksort, mergesort, heapsort, shellsort; Priority Queues: lists, heaps, binomial heaps, Fibonacci heaps; Graphs: representations, depth first search, breadth first search; Hashing: separate chaining, linear probing, quadratic probing; Search Trees: binary search trees, red-black trees, AVL trees, splay trees, B-trees; Strings: suffix arrays, tries; Randomized data structures: skip lists.

*Texts :*

1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.
2. M A Weiss, Data Structures and Problem Solving Using Java, Addison-Wesley, 1997.

*References :*

1. A M Tannenbaum, Y Langsam and M J Augenstein, Data Structures Using C++, Prentice Hall India, 1996.
2. A H Aho, J E Hopcroft and J Ullman, Data Structures and Algorithms, Addison-Wesley, 1987.
3. Robert Sedgewick, Algorithms in C++ Parts 1-4, Pearson Education, Third Edition, 1998.
4. Robert Sedgewick, Algorithms in C++ Part 5, Pearson Education, Third Edition, 2002.

| CS203 | DISCRETE MATHEMATICS | 3-1-0-8 |
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*Syllabus :* Set theory: sets, relations, functions, countability; Logic: formulae, interpretations, methods of proof, soundness and completeness in propositional and predicate logic; Number theory: division algorithm, Euclid's algorithm, fundamental theorem of arithmetic, Chinese remainder theorem, special numbers like Catalan, Fibonacci, harmonic and Stirling; Combinatorics: permutations, combinations, partitions, recurrences, generating functions; Graph Theory: paths, connectivity, subgraphs, isomorphism, trees, complete graphs, bipartite graphs, matchings, colourability, planarity, digraphs; Algebraic Structures: semigroups, groups, subgroups, homomorphisms, rings, integral domains, fields, lattices and boolean algebras.

*Texts :*

1. C L Liu, Elements of Discrete Mathematics, 2/e, Tata McGraw-Hill, 2000
2. R C Penner, Discrete Mathematics: Proof Techniques and Mathematical Structures, World Scientific, 1999.

*References :*

1. R L Graham, D E Knuth, and O Patashnik, Concrete Mathematics, 2/e, Addison-Wesley, 1994.
2. K H Rosen, Discrete Mathematics & its Applications, 6/e, Tata McGraw-Hill, 2007.
3. J L Hein, Discrete Structures, Logic, and Computability, 3/e, Jones and Bartlett, 2010.
4. N Deo, Graph Theory, Prentice Hall of India, 1974.
5. S Lipschutz and M L Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2/e, Tata McGraw-Hill, 1999.
6. J P Tremblay and R P Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997.

| CS204 | ALGORITHMS | 3-0-0-6 |
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*Syllabus :* Models of Computation: space and time complexity measures, lower and upper bounds; Design techniques: the greedy method, divide-and-conquer, dynamic programming, backtracking, branch and bound; Lower bound for sorting; Selection; Graph Algorithms: connectivity, strong connectivity, biconnectivity, topological sort, shortest paths, minimum spanning trees, network flow; The disjoint set union problem; String matching; NP-completeness; Introduction to approximate algorithms and Randomized algorithms.

*Texts :*

1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.
2. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison Wesley, 2005.

*References :*

1. A Aho, J E Hopcroft and J D Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley, 1974.
2. S Sahni, Data Structures, Algorithms and Applications in C++, McGraw-Hill, 2001.
3. M T Goodrich and R Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, John Wiley & Sons, 2001.

| CS205 | DIGITAL DESIGN | 3-0-0-6 |
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| *Syllabus :* Boolean Algebra and switching functions; Minimization and realization using logic gates, ROMs, PLAs, multiplexers; Circuits for code conversion; Flip-flops, registers, counters; Finite state model: State tables and diagrams; State minimization; Excitation functions of memory elements; Synthesis of synchronous sequential circuits; Representation and synthesis using ASM charts; Incompletely specified machines; Specification and synthesis of asynchronous sequential machines; Current trends in digital design: ASIC, FPGA, etc.; Number representation: fixed and floating point; Addition, subtraction, multiplication and division of numbers. |
| *Texts :*<br>1. M. Morris Mano and M. D. Ciletti, Digital Design, 4/e, Pearson Education, 2007.<br>2. R. H. Katz and G. Boriello, Contemporary Logic Design, 2/e, Prentice Hall of India, 2009. |
| *References :*<br>1. A. P. Malvino, D. P. Leach and G.Saha, Digital Principles and Applications, 7/e, McGraw Hill, 2010.<br>2. Z. Kohavi and N. Jha, Switching and Finite Automata Theory, 3/e, Cambridge University Press, 2010.<br>3. S. C. Lee, Digital Circuits and Logic Design, Prentice Hall of India, 2006.<br>4. J. F. Wakerly, Digital Design Principles and Practices, 4/e, Prentice Hall of India, 2008. |

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| **CS206** | **COMPUTER ORGANIZATION AND ARCHITECTURE** | **3-0-0-6** |
| *Syllabus :* Arithmetic and Logic Unit; Memory Organization; Instruction sets; RISC and CISC paradigms; Various addressing modes; Assembly language programming; Instruction interpretation: micro-operations and their RTL specification; CPU design: Hardwired and Microprogrammed; I/O transfer techniques: Program controlled, Interrupt controlled and DMA; Introduction to computer buses, peripherals and current trends in architecture. | | |
| *Texts :*<br>1. William Stallings, Computer Organization and Architecture: Designing for Performance, 8/e, Pearson Education India. 2010.<br>2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design, 4/e, Morgan Kaufmann, 2008. | | |
| *References :*<br>1. A. S. Tanenbaum, Structured Computer Organization, 5/e, Prentice Hall of India, 2009.<br>2. V. C. Hamacher, Z. G. Vranesic and S. G. Zaky, Computer Organization, 5/e, McGraw Hill, 2002.<br>3. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, 4/e, Morgan Kaufmann, 2006.<br>4. D. V. Hall, Microprocessors and Interfacing, 2/e, McGraw Hall, 2006. | | |
| **CS208** | **OBJECT ORIENTED PROGRAMMING** | **3-0-0-6** |
| *Syllabus :* Principles of Object Oriented Programming; Tokens, expressions and control structures; Classes and objects; Object initialization and cleanup; Operator overloading and type conversion; Inheritance, extending classes; Pointers, virtual functions and polymorphism; Working with files; Generic programming with templates; Introduction to Object-Oriented analysis and design | | |
| *Texts :*<br>1. Object-Oriented Programming in C++ By Robert Lafore<br>2. Object Oriented Programming with C++ by Balaguruswamy, TMH | | |

*References :*
1. Object Oriented Programming By- Budd, Addison Wesley.
2. Mastering C++ By K.R Venugopal , Rajkumar, TMH.
3. An Introduction to Object Oriented Programming with C++ by Timthy Budd, Addition-Wesley
4. C++ and Object-Oriented Programming By - Kip R. Irvine, Prentice Hall.

| CS231 | DATA STRUCTURES LABORATORY | 0-0-3-3 |
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*Syllabus :* Programming Laboratory will be set in consonance with the material covered in CS201. All programming assignments are to be in C/C++/Java.

*Texts :*

*References :*
1. J Gosling, B Joy, G L Steele and G Bracha, The Java Language Specification, 2/e, Addison-Wesley, 2000.
2. B Stroustrup, The C++ Programming Language, 3/e, Addison-Wesley Longman Reading MA,1997.
3. S B Lippman, C++ Primer, 2/e, Addison-Wesley, 1991.
4. T Budd, C++ for Java Programmers, Addison Wesley, 1999.
5. M C Daconta, Java for C/C++ programmers, John Wiley & Sons, 1996.

| CS233 | DIGITAL DESIGN LABORATORY | 0-0-3-3 |
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*Syllabus :* Experiments related to topics covered in CS221: Digital Design.

*Texts :*

*References :*
1. Relevant Analog and Digital IC and component manuals.

| CS202 | FORMAL LANGUAGES AND AUTOMATA THEORY | 3-1-0-8 |
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*Syllabus :* Alphabets, languages, grammars; Finite automata: regular languages, regular expressions; Context-free languages: pushdown automata, DCFLs; Context sensitive languages: linear bounded automata; Turing machines: recursively enumerable languages; Operations on formal languages and their properties; Chomsky hierarchy; Decision questions on languages.

*Texts :*
1. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2/e, Pearson Education, 2000.

*References :*

1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
2. H. R. Lewis, C. H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia, 2001.
3. D. C. Kozen, Automata and Computability, Springer-Verlag, 1997.

| MA202 | PROBABILITY AND RANDOM PROCESSES | 3-0-0-6 |
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*Syllabus :* Axiomatic construction of the theory of probability, independence, conditional probability, and basic formulae, random variables, probability distributions, functions of random variables; Standard univariate discrete and continuous distributions and their properties, mathematical expectations, moments, moment generating function, characteristic functions; Random vectors, multivariate distributions, marginal and conditional distributions, conditional expectations; Modes of convergence of sequences of random variables, laws of large numbers, central limit theorems.

Definition and classification of random processes, discrete-time Markov chains, Poisson process, continuous-time Markov chains, renewal and semi-Markov processes, stationary processes, Gaussian process, Brownian motion, filtrations and martingales, stopping times and optimal stopping.

*Texts:*

1. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2000.
2. J. Medhi, Stochastic Processes, 3rd Ed., New Age International, 2009.
3. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

*References :*

1. G.R. Grimmett and D. R. Stirzaker, Probability and Random Processes, Oxford University Press, 2001.
2. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
3. K.S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, Wiley India, 2008.
4. S.M. Ross, Stochastic Processes, 2nd Ed., Wiley, 1996.
5. C.M. Grinstead and J. L. Snell, Introduction to Probability, 2nd Ed., Universities Press India, 2009.

| CS232 | ALGORITHMS LABORATORY | 0-0-3-3 |
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*Syllabus :* Programming different algorithms studied in theory course (CS204: Algorithms); running on large data sets and observing change in time with input size.

*Texts :*

1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.

*References :*
1. A Aho, J E Hopcroft and J D Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley, 1974.

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| **CS234** | **OBJECT ORIENTED PROGRAMMING LABORATORY** | **0-0-3-3** |

*Syllabus :* Programs will be based on theoretical topics of the course (CS208: Object Oriented Programming) covered in the class.

*Texts :*

1. Object-Oriented Programming in C++ By Robert Lafore

*References :*
1. Object Oriented Programming with C++ by Balaguruswamy, TMH

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| **CS236** | **PERIPHERALS AND ACCESSORIES LABORATORY** | **0-0-3-3** |

*Syllabus :* Microprocessor architecture, Microprocessor programming, Assembly Language of 8085 and 8086 microprocessors, Software controlled serial and parallel I/O in 8085, Use of programmable interrupt controller, programmable peripheral interface ( 8255), DMA controller, PIT (8253) and DMA. Experiments related to interfacing ADC, DAC, Motors, Timers, Serial and Parallel ports, etc. to such kits/boards.

*Texts :*
1. Ramesh Gaonkar, Microprocessor Architecture, Programming, and Applications with 8085, 5/e, Penram International Publishing, 2009.
2. D. V. Hall, Microprocessors and Interfacing, 2/e, McGraw Hall, 2006.
3. Relevant Analog and Digital IC and component manuals.

*References :*

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| **MA301** | **OPTIMIZATION** | **3-0-0-6** |

*Syllabus :* Classification and general theory of optimization; Linear programming (LP): formulation and geometric ideas, simplex and revised simplex methods, duality and sensitivity, interior-point methods for LP problems, transportation, assignment, and integer programming problems; Nonlinear optimization, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, numerical methods for nonlinear optimization, convex optimization, quadratic optimization; Dynamic programming; Optimization models and tools in finance.

Texts:
1. D. G. Luenberger and Y. Ye, Linear and Nonlinear Programming, 3rd Ed., Springer India, 2008.
2. N. S. Kambo, Mathematical Programming Techniques, East-West Press, 1997.

References:
1. E. K. P. Chong and S. H. Zak, An Introduction to Optimization, 2nd Ed., Wiley India, 2001.
2. M. S. Bazarra, H. D. Sherali and C. M. Shetty, Nonlinear Programming Theory and Algorithms, 3rd Ed., Wiley India, 2006.
3. S. A. Zenios (ed.), Financial Optimization, Cambridge University Press, 2002.

4. K. G. Murty, Linear Programming, Wiley, 1983.
5. D. Gale, The Theory of Linear Economic Models, The University of Chicago Press, 1989.

| CS301 | SOFTWARE ENGINEERING | 3-0-0-6 |
|---|---|---|

*Syllabus :* Software and Software Engineering; The Software Process: Process models; Modeling: Requirements engineering, requirements modeling, UML, design concepts, etc.; Quality Management; Product metrics; Process and project metrics; Software estimation techniques; Software testing strategies; Project scheduling; Risk management; Maintenance.

*Texts :*

1. Pressman, R.S., Software Engineering: A Practioner's Approach, McGraw Hill, seventh edition, 2010.

*References :*

1. Sommerville, Ian, Software Engineering, Addison-Wesley, fifth edition, 2000.
2. Jalote, P., An Integrated Approach to Software Engineering, Narosa Publishing House, second edition, 2003.
3. Bennett S., McRobb S. & Farmer R., Object Oriented Systems Analysis and Design using UML, Tata McGraw-Hill, second edition, 2004.

| CS303 | OPERATING SYSTEMS | 3-0-0-6 |
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*Syllabus :* Process Management: process, thread, scheduling; Concurrency: mutual exclusion, synchronization, semaphores, deadlocks; Memory Management: allocation, protection, hardware support, paging, segmentation; Virtual Memory: demand paging, allocation, replacement, swapping, segmentation, TLBs; File Management: naming, file operations and their implementation; File Systems: allocation, free space management, directory management, mounting; I/O Management: device drivers, disk scheduling.

*Texts :*

1. Silberschatz, A. and Galvin, P. B. Operating System Concepts. 8/e. Wiley, 2008.

*References :*

1. Stalling, W. Operating Systems: Internals and Design Principles. 6/e. Pearson, 2008.
2. Tanenbaum, A. S. Modern Operating System. 3/e. Pearson, 2007.
3. Dhamdhere, D. M. Operating SystemsA Concept Based Approach, McGrawHill, 2008

| CS304 | COMPILERS | 3-0-0-6 |
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*Syllabus :* Overview of different phases of a compiler: front-end; back-end; Lexical analysis: specification of tokens, recognition of tokens, input buffering, automatic tools; Syntax analysis: context free grammars, top down and bottom up parsing techniques, construction of efficient parsers, syntax-directed translation, automatic tools; Semantic analysis: declaration processing, type checking, symbol tables, error recovery; Intermediate code generation: run-time environments, translation of language constructs; Code generation: flow-graphs, register allocation, code-generation algorithms; Introduction to code optimization techniques.

*Texts :*

1. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques, and Tools, 2nd Edition, Prentice Hall, 2009.

*References :*
1. V. Raghavan, Principles of Compiler Design, McGrawHill, 2010.
2. C.N. Fischer, R.J. Le Blanc, Crafting a Compiler with C, Pearson Education, 2009.
3. K. D. Cooper, L. Torczon, Engineering a Compiler, Morgan Kaufmann Publishers, 2004.

| CS305 | DATA COMMUNICATION | 3-1-0-8 |
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*Syllabus :* Basics of Digital communications: Signals, noise, Nyquist rate, Shannon capacity; Analog transmission: modulation techniques, fundamentals of modems, FDM; Digital transmission: PCM, ADPCM, line coding, error handling techniques, TDM, xDSL, spread spectrum; Transmission media: Guided (twisted pair, coaxial, fiber optic) and unguided media; Balanced and unbalanced signalling, interfacing; Principles of switching; Local area networks: Ethernet, Fast Ethernet, introduction to Gigabit Ethernet and WLANs; Hubs, bridges and switches;

*Texts :*
1. W. Stallings, Data and Computer Communications, 8th Ed, Pearson India, 2007.
2. B. Forouzan, Data Communications and Networking, 4th Ed, Tata Mcgraw Hill, 2006.

*References :*
1. A. S. Tanenbaum, Computer Networks, 4th Ed, Pearson India, 2003.
2. J. Quinn, Digital Data Communications, 1st Ed, Prentice Hall Career and Technology, 1995.
3. P. C. Gupta, Data Communications and Computer Networks, 2nd Ed, Prentice Hall of India, 2009.
4. F. Halsall, Data Communications, Computer Networks and Open Systems, 4th Ed, Addison Wesley, 1996.

| CS307 | MACHINE LEARNING | 3-0-0-6 |
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*Syllabus :* **Introduction:** Basic concepts; **Supervised learning:** Supervised learning setup, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms; **Learning theory:** Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning; **Unsupervised learning:** Clustering K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis); **Reinforcement learning and control:** MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), LQG, Q-learning. Value function approximation, Policy search. Reinforce. POMDPs.

*Texts :*
1. Ethem Alpaydin, Introduction to Machine Learning, Second Edition, PHI, 2010

2. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.

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| *References :* |

| CS331 | SOFTWARE ENGINEERING AND SYSTEM SOFTWARE LABORATORY | 0-0-3-3 |
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| *Syllabus :* Laboratory will be set in consonance with the material covered in CS301. The syllabus also includes Overview of Unix system, commands and utilities; Basic Linux administration and installation: grub, rpm, yum, disk partitioning; Basic Linux utilities, logging, backup, authentication; Internet mail system: send mail, elm, mail administration; Program Maintenance: make, sccs, debugging with gdb and ddd; Archiving: shar, tar; Shell use: redirection, .cshrc, environment variables; Regular Expression parsing: grep, egrep, sed, awk; Shell programming: bash; Scripting Languages like Perl, Python, Java Script; Database Driven Web Site: PHP and MySQL; | | |
| *Texts :* | | |
| *References :*<br>1. Bennett S., McRobb S. & Farmer R., Object Oriented Systems Analysis and Design using UML, Tata McGraw-Hill, second edition, 2004.<br>2. J. Greenspan and B. Bulger, MySQL/PHP Database Applications, M&T Books, 2008<br>3. E. Nemeth, G. Snyder and T. R. Hein, Linux Administration Handbook, Prentice Hall PTR, 2002.<br>4. D. Curry, UNIX Systems Programming for SVR4, OReilly, 1996.<br>5. S. Kochan and P. Wood, Unix Shell programming, 3rd Ed, SAMS, 2003.<br>6. D. Flanagan, Javascript: The Definitive Guide, Fifth Edition, O'REILLY, 2006.<br>7. D. Gosselin, PHP Programming with MySQL, Course Technology, 2006. | | |

| CS333 | OPERATING SYSTEMS LABORATORY | 0-0-3-3 |
|---|---|---|
| *Syllabus :* Programs on the use of pthread library, process creation, shared memory, message queues, semaphores in Unix/Linux using simple examples, Development of user-level modules for memory management, file caching etc. Programming assignments to build parts of an OS kernel. Use of a teaching package such as Nachos, Pintos. | | |
| *Texts :*<br>1. Tanenbaum, A. S. Modern Operating System. 3/e. Pearson, 2007.<br>2. Dhamdhere, D. M. Operating SystemsA Concept Based Approach, McGrawHill, 2008<br>3. Reference manuals for Nachos and Pintos. | | |
| *References :* | | |

| CS335 | MACHINE LEARNING LABORATORY | 0-0-3-3 |
|---|---|---|
| *Syllabus :* Programs will be based on theoretical topics of the course (CS307: Machine Learning) covered in the class. | | |
| *Texts :* | | |
| *References :* | | |

| CS302 | DATABASES | 3-0-0-6 |
|---|---|---|
| *Syllabus :* Data models with emphasis on the relational model; Database design with E-R model; Relational algebra and calculus; query Languages (specifically SQL); RDBMS design; File & system structure: indexed sequential, hashed, dynamic hashed, B-trees; Query processing; Concurrency control; error recovery; security; Case studies like ORACLE, Mysql, etc.; Introduction to Open Database Connectivity, Client-Server environment etc. | | |
| *Texts :*<br>1. A. Silberschatz, H. F. Korth and S. Sudarshan, Database System Concepts, 5/e, McGraw Hill, 2006<br>2. R. Ramakrishnan and J. Gehrke, Database Management Systems, 3/e, McGraw Hill, 2003 | | |
| *References :*<br>1. Elmasri R, Navathe S B, Fundamentals of Database Systems, Benjamin Cummings Publishing Company, 1994.<br>2. ONeil P., Database : Principles, Programming, Performance, Morgan Kaufmann, 1994.<br>3. Theorey T J, Database Modeling & Design, 2/e, Morgan Kaufmann Publishers, 1994.<br>4. Melton J, Simon A R, SQL: A Complete Guide, Morgan Kaufmann Publishers, 1993.<br>5. H. GarciaMolina, J. D. Ullman and J. Widom, Database Sytems The Complete Book,1/e, Pearson Education, 2007 | | |

| CS306 | COMPUTER NETWORKS | 3-0-0-6 |
|---|---|---|
| *Syllabus :* Evolution of computer networks; Data link layer: Framing, HDLC, PPP, sliding window protocols, medium access control, Token Ring, Wireless LAN; Virtual circuit switching: Frame relay, ATM; Network Layer: Internet addressing, IP, ARP, ICMP, CIDR, routing algorithms (RIP, OSPF, BGP); Transport Layer: UDP, TCP, flow control, congestion control; Introduction to quality of service; Application Layer: DNS, Web, email, authentication, encryption. | | |
| *Texts :*<br>1. L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, 4th Ed, Elsevier India, 2007.<br>2. A. S. Tanenbaum, Computer Networks, 4th Ed, Pearson India, 2003. | | |
| *References :*<br>1. J. F. Kurose and K. W. Ross, Computer Networking: A Top Down Approach, 3rd Ed, Pearson India, 2005.<br>2. D. E. Comer, Internetworking with TCP/IP Vol. 1, 5th Ed, Prentice Hall of India, 2006.<br>3. S. Keshav, An Engineering Approach to Computer Networking, 1st Ed, Pearson India, 1999.<br>4. B. Forouzan, Data Communications and Networking, 4th Ed, Tata Mcgraw Hill, 2006. | | |

| CS308 | INFORMATION STORAGE AND RETRIEVAL | 3-1-0-8 |
|---|---|---|
| *Syllabus :* Introduction: concepts and terminology of information retrieval systems, Significance of information retrieval and storage, Information Retrieval Vs Information Extraction; Indexing: inverted files, encoding, Zipf's Law, compression, boolean queries; Fundamental IR models: Boolean, Vector Space, probabilistic, TFIDF, Okapi, language modeling, latent semantic indexing, query processing and refinement techniques; Performance Evaluation: precision, recall, F-measure; Classification: Rocchio, | | |

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|---|
| Naive Bayes, k-nearest neighbors, support vector machine; Clustering: partitioning methods, k-means clustering, hierarchical; Introduction to advanced topics: search, relevance feedback, ranking, query expansion. |
| *Texts :*<br>1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schtze, Introduction to Information Retrieval, Cambridge University Press. 2008<br>2. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Modern Information Retrieval, Addison Wesley, 1st edition, 1999. |
| *References :*<br>1. Soumen Chakrabarti, Mining the Web, Morgan-Kaufmann Publishers, 2002.<br>2. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Springer, Corr. 2nd printing edition, 2009.<br>3. David A. Grossman, Ophir Frieder, Information Retrieval: Algorithms and Heuristics, Springer, 2nd edition, 2004.<br>4. William B. Frakes, Ricardo Baeza-Yates, Information Retrieval Data Structures and Algorithms, Prentice Hall, 1992.<br>5. G. Salton, M. J. McGill, Introduction to Modern Information Retrieval, McGraw-Hill, 1986.<br>6. C. J. Van Rijsbergen, Information Retrieval, Butterworth-Heinemann; 2nd edition, 1979. |

| **CS332** | **DATABASES LABORATORY** | **0-0-3-3** |
|---|---|---|
| *Syllabus :* Familiarization with various databases packages like Microsoft Access, ORACLE, MySql, SQL Server, DB2 etc. Client-server and 3 tier web enabled database programming. Use of Application servers. Design and implementation of a Database application using a multi-user DBMS. | | |
| *Texts :*<br>1. J. Melton and A. R. Simon, SQL: A Complete Guide, Morgan Kaufmann, 1993<br>2. S. Feuerstein and B. Pribyl, Oracle PL/SQL Programming, 5/e, O'Reilly, 2009<br>3. J. Greenspan and B. Bulger, MySQL/PHP Database Applications, M&T Books, 2008 | | |
| *References :* | | |

| **CS334** | **COMPILERS AND SYSTEM PROGRAMMING LABORATORY** | **0-0-3-3** |
|---|---|---|
| *Syllabus :* Programming assignments to build a compiler for a subset of a C-like programming language, using tools such as Lex / Flex / JLex and Yacc / Bison / CUP etc. C-Macro; Linker and Loader: Design of Linkers and Loaders in C-Compile and go loader, Absolute Loaders, Relocating Loaders, Direct Linking Loaders.<br>Documentation and Presentation: Document writing and Slides using LaTex; | | |
| *Texts :*<br>1. D. Brown, J. Levine, T. Mason, Lex and Yacc, 2nd Edition, O'REILLY Publications.<br>2. J. J. Donovan, Systems Programming, 45th Reprint, Tata Mc-Graw-Hill, 1991<br>3. D. M. Dhamdhere, Systems Programming And Operating Systems, Tata Mc-Graw-Hill, 2 Revised edition, 2008. | | |
| *References :*<br>1. J. Levine, Linkers and Loaders, MORGAN KAUFFMAN, 1999.<br>2. Leslie Lamport, LaTeX: A Document Preparation System, 2nd Edition, Addison-Wesley Series, 1994. | | |

**CS336 COMPUTER NETWORKS LABORATORY 0-0-3-3**

*Syllabus :* Unix network measurement and analysis tools, Wireshark, Socket interface and programming, RPC, RMI, HTML, HTTP, CGI, XML, Client-server programming using TCP and UDP sockets, implementation of ARQ techniques, implementation of subset of TCP stack at user level, implementation of simplified versions of application layer protocols such as SMTP/HTTP/FTP etc., Assignments using Network Simulators.

*Texts :*
1. W. R. Stevens, UNIX Network Programming, Volume 1: Networking APIs: Sockets and XTI, 2nd Ed, Prentice Hall, 1998.
2. S. S. Panwar, S. Mao, J. Ryoo, and Y. Li, TCP/IP Essentials: A Lab-based Approach, Cambridge Press, 2004.

*References :*

| **CS401** | **COMPUTER GRAPHICS** | **3-0-0-6** |
|---|---|---|

*Syllabus :* Introduction and organization of an interactive graphics system; Scan conversion: line, circle, and ellipse; Filling: rectangle, polygon, ellipse, and arc; Clipping: line, circle, ellipse, and polygon; Antialiasing: unweighted and weighted area sampling, and Gupta-Sproull methods; Transformations: 2D and 3D, homogeneous coordinates, composite and window-to-viewport transformations; 3D View: projections, specification and implementation of 3D view; Curves and Surfaces: polygon meshes, parametric cubic curves and bicubic surfaces, Hermite, Bezier, and B-splines curves and surfaces; Quadric surfaces; Solid Modeling: Boolean set operations, spatial partitioning methods (occupancy enumeration, octree, and binary space partitioning tree); Hidden line and surface removal: z-buffer, list-priority, and scan line algorithms, algorithms for binary space partitioning trees and octrees, and ray tracing; Shading: illumination model, polygon shading (interpolated, Goursud, and Phong), texture mapping, shadow determination (scan line and z-buffer algorithms), transparency, global illumination model; Introduction to GPU and animation.

*Texts :*
1. D. Hearn and M. P. Baker, Computer Graphics with OpenGL, 3/e, Pearson, 2009.

*References :*
1. E. Angel. Interactive Computer Graphics: A Top-Down Approach using OpenGL, 5/e, Pearson, 2009.
2. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes. Computer Graphics: Principles and Practice in C, 2/e, Addison-Wesley, 1995.
3. P. Shirley and S. Marschner. Computer Graphics. India Edition, Cengage Learning, 2009.
4. F. S. Hill. Computer Graphics using OpenGL, 3/e, Pearson, 2009.

| **MA203** | **NUMERICAL METHODS** | **3-0-0-6** |
|---|---|---|

*Syllabus :* **Numerical Analysis:** Solution of algebraic and transcendental equations by bisection method, iteration method, Regular-Falsi (False position) method, Newton-Raphson method, Solution of Simultaneous linear equations by Gauss Elimination and Gauss-Seidal method; **Interpolation:** Concept of interpolation, difference operators, divided difference interpolation, Newton's forward, backward interpolation, Lagrange's interpolation, Starling and Bessel's interpolation, Numerical differentiation (1st and 2nd order), Numerical integration (Trapezoidal, Simpson's one-third, Weddle's rule); **Numerical Solution of Ordinary differential equation:** Taylor's method, Picard's method, Runge's method, Runge-Kutta's method, Euler's method and Euler's modified method, Predictor-corrector method.

*Texts :*
1. Jain, Iyengar and Jain : Numerical Methods for Engineers and Scientists, Wiley Eastern

*References :*
1. S. D. Cante and C. de Boor, Elementary Numerical Analysis, an algorithmic approach, McGraw-Hill.
2. Gerald and Wheatley : Applied Numerical Analysis, Addison- Wesley.

| **CS471** | **COMPUTER GRAPHICS LABORATORY** | **0-0-3-3** |
|---|---|---|

*Syllabus :* Programming assignments to learn and practice the concepts taught in the theory course CS461.

*Texts :*
1. OpenGL programming Guide (the Red Book). Online tutorial, available at http://fly.cc.fer.hr/~unreal/theredbook/
2. D. P. Mukherjee and D. Jana. Computer Graphics: Algorithms and Implementations. PHI Learning, 2010.

*References :*

| **CS473** | **PROJECT - I** | **0-0-6-6** |
|---|---|---|

*Syllabus :* Each student will undertake a sizeable project involving survey of literature, development of new techniques and/or implementation of systems, writing of reports etc. under the guidance of one or more faculty members.

*Texts :*

*References :*

| **CS482** | **PROJECT - II** | **0-0-9-9** |
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*Syllabus :* Each student will undertake a sizeable project involving survey of literature, development of new techniques and/or implementation of systems, writing of reports etc. under the guidance of one or more faculty members.

*Texts :*

*References :*

**Department Electives**

| Course ID | Course Name | Credit |
|---|---|---|
| CS 412 | Optimization methods | 6 |
| CS 414 | Computation number theory & cryptography | 6 |
| CS 416 | Information & randomness | 6 |
| CS 418 | Advanced operating systems | 6 |
| CS 420 | Information transmission & security | 6 |
| CS 422 | Topics in networks | 6 |
| CS 424 | Web development technologies | 6 |
| CS426 | Big Data | 6 |
| CS 428 | Wireless networks | 6 |
| CS 430 | Linux Kernals: Implementation & security | 6 |
| CS 432 | Enterprise systems | 6 |
| CS 434 | Performance modelling of communication & computer systems | 8 |

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| CS 436 | Artificial intelligence | 6 |
| CS 438 | Principles of robotics | 6 |
| CS 440 | Intelligences systems & interfaces | 6 |
| CS 442 | Pattern recognition | 6 |
| CS 444 | Fundamental of information retrieval | 8 |
| CS 446 | Digital Watermarking | 6 |
| CS 448 | Steganography | 6 |
| CS450 | Video Processing | 6 |
| CS452 | Natural Language Processing | 6 |
| CS454 | Cloud Computing | 6 |
| CS 411 | Parallel algorithms | 6 |
| CS 413 | Computational geometry | 6 |
| CS 415 | Structural complexity | 6 |
| CS 417 | Hierarchial memory algorithm | 6 |

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| CS 419 | Logic in computer science | 6 |
| CS 421 | Learning with Kernals | 6 |
| CS 423 | Computational topology | 6 |
| CS 425 | Advanced computer architecture | 6 |
| CS 427 | Formal methods for system verification | 6 |
| CS 429 | Semantics for programming languages | 6 |
| CS 431 | Functional & logic programming | 6 |
| CS 433 | Advanced compilers | 6 |
| CS 435 | Distributed systems | 6 |
| CS 437 | Internet protocols | 6 |
| CS 439 | Wireless sensor networks | 6 |
| CS 441 | Machine learning | 6 |
| CS 443 | Data mining | 6 |
| CS 445 | Multimedia systems | 6 |

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|---|---|---|
| CS 447 | Human computer interaction | 8 |
| CS 449 | Computational system biology | 6 |
| CS 451 | Digital Image Processing | 6 |
| CS 453 | Mobile robotics | 6 |
| CS 455 | Computer & network security | 6 |

**CS411** **PARALLEL ALGORITHMS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Theoretical models of parallel computation: variants of the PRAM model, interconnection networks, synchronous and asynchronous models. Performance of parallel algorithms. Basic techniques: balanced trees, recursive doubling, divide and conquer, partitioning, pipelining, accelerated cascading, symmetry breaking.List ranking, the Euler tour technique, tree contraction. Algorithms for searching, merging and sorting. Graph algorithms: Connected Components, Colouring. Parallel algorithms on interconnection networks and other architectures. Algorithms on asynchronous models. Limits to parallelizability. NC-reductions, P-completeness.

***Texts :***

1. J. Jaja, An Introduction to Parallel Algorithms, Addison Wesley, 1992.
2. F. T. Leighton, Introduction to Parallel Algorithms and Architectures: Arrays,Trees,Hypercubes,Morgan Kaufmann Publishers, San Mateo,California,1992.

***References :***

1. J. H. Reif, Synthesis of Parallel Algorithms, Morgan Kaufmann Publishers, San Mateo, California.
2. S. G. Akl, Parallel Computation: Models and Methods, Prentice Hall, 1996.

**CS513** **COMPUTATIONAL GEOMETRY** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Algorithmic design paradigms (divide and conquer, incremental, sweep line, and prune and search) and basic data structures (segment and interval trees). Geometric searching: point locations (slab and chain methods) and range searching (kD and range trees); Convex hull: Graham's scan, gift wrapping, quick hull, divide-and-conquer; Voronoi diagram and Delaunay triangulation: properties and construction algorithms (sweep line and divide-and-conquer algorithms). Visibility and Art gallery problems, motion planning and shortest paths. Arrangements and duality; Line segments intersection problem; closest pair computation.

***Texts :***

1. F. P. Preparata and M. I. Shamos, Computational Geometry: An Introduction, Springer-Verlag, 1985.

***References :***

1. J. O'Rourke, Computational Geometry in C, 2nd Ed, Cambridge University Press, 1998.
2. M. Laszlo, Computational Geometry and Computer Graphics in C++, Prentice-Hall, 1996.
3. M. De Berg, M. van Kreveld, M. Overmars, O. Schwarzkopf, Computational Geometry: Algorithms and Applications, Springer -Verlag, 1997.

**CS415** **STRUCTURAL COMPLEXITY** **3-0-0-6**

*Pre-requisites :* CS204

***Syllabus :*** Models of computation: automata, Turing machines, oracle Turing machines. Time and space bounded computations. Central complexity classes: invertibility, honesty, NP-Complete Sets, PSPACE-complete sets, padding arguments, space bounded reducibility. Time bounded reducibility: relativized classes, tally and sparse sets, self-reducibility. Nonuniform complexity: Boolean circuit complexity, polynomial advice. logarithmic advice. Self-producible circuits. probabilistic complexity classes. Uniform diagonalization. The polynomial time hierarchy. Alternation, Kolmogorov complexity.

***Texts :***

***References :***

1. J. L. Balcazar, J. Diaz and J. Gabarro, Structural Complexity, Vols 1 & 2, EATCS Monographs, Springer-Verlag, 1987.
2. J. Van Leeuwen, Handbook of Theoretical Computer Science, Vol A, Elsevier and MIT Press, 1990.

**CS417** **HIERARCHICAL MEMORY ALGORITHMS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Hierarchical memory levels; performance characteristics; Parallel disk model. Fundamental I/O operations. Design and analysis of efficient external memory algorithms for some representative problems. Sorting, permutation, searching. Depth first search, breadth first search, Minimum spanning forest, connected components, single source shortest path, transitive closure. hashing, string matching. External Memory Data Structures. Cache efficient algorithms. Applications in various areas, for example, Computational geometry.

***Texts :***

***References :***

1. J. S. Vitter. External Memory Algorithms and Data Structures: Dealing with MASSIVE DATA, ACM Computing Surveys, 33(2), June 2001, 209-271.
2. Course Material on External Memory Algorithms and Data Structures: http://www.brics.dk/~gerth/emF99/
3. Other research papers.

**CS419** **LOGIC IN COMPUTER SCIENCE** **3-0-0-6**

*Pre-requisites :* CS203, CS302

***Syllabus :*** Propositional Logic: Syntax, Proof System, Semantics, Soundness and completeness, Compactness, Normal Forms, Resolution, Horn Clauses, propositional satisfiability solvers, Complexity. First Order Logic: Syntax, Proof System, Semantics, Soundness and Completeness, Compactness, Herbrand Models, Unification and Resolution, Logic Programming and SLD Resolution, Decidability and Undecidability, Expressiveness, Ehrenfeucht-Fraisse Games, Applications. Modal Logic: Possibility and Necessity, Knowledge or Belief, Frames and Forcing, Modal Tableaux, Soundness and Completeness, Modal Axioms and Special Accessibility Relations, Logics of knowledge. Applications.

***Texts :***

1. A. Nerode and R. A. Shore, Logic for Applications, Springer-Verlag, 1997, 2nd edition.

***References :***

1. M. Huth and M. Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, 2nd Ed, Cambridge University Press, 2004.
2. M. Fitting, First-order Logic and automated theorem proving, Springer-Verlag, 1990.
3. J. H. Gallier, Logic for Computer Science: Foundations of Automatic Theorem Proving (Harper & Row Computer Science and Technology Series), John Wiley & Sons, 1986.

**CS412** **OPTIMIZATION METHODS** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction to Linear Programming: Connections with Geometry. Simplex Method: Duality Theorem. Complementary Slackness. Farkes' Lemma. Revised Simplex Method. General LP Problems: Infeasibility. Sensitivity Analysis. Primal-Dual Algorithm: Applications to Network Flow and Matching. Efficient Algorithm: Linear Programming in fixed dimensions. Randomized Linear Programming. Integer Linear Programming: Total Unimodularity. Semidefinite Programming: Application to MAXSAT problems.

***Texts :***

1. V. Chavtal, Linear Programming, W. H. Freeman and Company, New York, 1983.
2. C. H. Papadimitriou and K. steiglitz, Combinatorial optimization: Algorithms and Complexity, Dover Publications, Inc., New York, 1998.

***References :***

1. M. Grotschel, L. Lovasz and A. Schrijver, Geometric Algorithms and Combinatorial Optimization, John Wiley & Sons, Inc., New York, 1998.
2. W. Cook, W. H. Cunningham, W. R. Pulleyblank and A. Schrijver, Combinatorial Optimization, John Wiley & Sons, Inc., New York, 1998.
3. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
4. Related publications in Journals/Conferences

**CS414** **COMPUTATIONAL NUMBER THEORY AND CRYPTOGRAPHY** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Modular Arithmetic: Solving Modular Linear Equations, the Chinese Remainder Theorem, Modular Exponentiation, and Discrete Logarithm Problem; GCD Computation: Euclid's Algorithm, Extended Euclid's Algorithm; Key Exchange: Diffie Hellman, ElGamal, Massey-Omura, Computation of Generators of Primes; Public Key Cryptosystem: RSA, Different Attacks & Remedies; Primality Testing: Pseudoprimality Testing, Quadratic Residues, Randomized Primality Test & Deterministic Polynomial Time Algorithm; Factorization: Quadratic-Sieve Factoring Algorithm, Pollard-Rho Method; Elliptic Curve Cryptosystem: Theory of Elliptic Curves, Elliptic Curve Encryption & Decryption Algorithms, Security of Elliptic Curves Cryptography, Elliptic Curve Factorization; Cryptographic Hash Functions: MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA-1), Security of Hash Functions & Birthday Attack; Digital Signatures: Authentication Protocols, Digital Signature Standards (DSS).

***Texts :***

1. T. H. Cormen, C. E. Leiserson, R. Rivest and C. Stein, Introduction to Algorithms, 2nd Edition, Prentice Hall, 2002.
2. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag, New York, May 2001.

***References :***

1. Oded Goldrich, Foundations of Cryptography-Basics, vol-1, Cambridge Univ. Press, 2005.
2. Oded Goldrich, Foundations of Cryptography-Applications, vol-2, Cambridge Univ. Press, 2005.
3. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
4. William Stallings, Cryptography and Network security: Principles and Practice, 3rd Ed, Prentice Hall, 2003.

**CS416** **INFORMATION AND RANDOMNESS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Definitions of randomness: statistical (Martin-Loef, Solovay), based on program size complexity (Chaitin). Equivalence of the definitions. Random numbers: Properties of random and pseudo-random sequences. Provably secure pseudo-random generators. Examples of pseudo-random generators: Fake One-Time Pads, Period of a pRNG, Congruential Generators, Feedback Shift Generators, Blum-Blum-Shub Generator, Naor-Reingold Generator. Statistical tests for random numbers: Chi-square test, Kolmogorov-Smirnov test, empirical / theoretical / spectral tests. Non-uniform random sequences. Randomized algorithms. Derandomization techniques. Pseudo-random functions and permutations. Sequences of families of PSFs and PSPs. Applications: cryptographically strong hashing, prediction, learning, identify friend or foe, private-key encryption.

***Texts :***

***References :***

1. G. J. Chaitin, Algorithmic Information Theory, Cambridge University Press, 2004.
2. G. J. Chaitin, Information, Randomness and Incompleteness, 2nd edition, World Scientific, 1990.
3. G. J. Chaitin, Exploring Randomness, Springer-Verlag, 2001.
4. S. Goldwasser and M. Bellare, Lecture Notes in Cryptography, http://www-se.ucsd.edu/~mihir/papers/gb.pdf, 2001.
5. P. Garrett, Making and Breaking Codes: Introduction to Cryptology, Prentice-Hall, 2000.
6. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
7. D. E. Knuth, The Art of Computer Programming, 3rd Ed, Vol 2, Seminumerical Algorithms, Addison-Wesley, 1998.
8. W. Feller, An Introduction to Probability Theory and its Applications, Vol 1, Wiley Eastern, 1968.

**CS421** **LEARNING WITH KERNELS** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction: Data representation, similarity, statistical learning theory, hyper-plane classifiers, support vector classification, support vector regression, kernel principal component analysis; Kernels: Product features, representation of similarities in linear spaces, examples and properties of kernels; Risk and loss functions: Loss functions, test error, expected risk, statistical perspective, robust estimators; Regularization: Regularized risk functional, representer theorem, regularization operators, translation invariant kernels, dot product kernels; Optimization: Convex optimization, unconstrained problems, constrained problems; Support vector machines: Separating hyper-planes, role of margin, optimal margin hyper-planes, nonlinear support vector classifiers, soft margin hyper-planes, multi-class hyper-planes; Single class problems: introduction, algorithms, optimization, theory; Regression estimation: Linear regression with insensitive loss function, dual problems, $\nu$-SV regression; Implementation: Tricks of the trade, sparse greedy matrix approximation, subset selection methods, sequential minimal optimization, iterative methods; Designing kernels: Tricks for constructing kernels, string kernels, natural kernels.

***Texts :***

1. Bernhard Schlkopf and Alexander J. Smola. Learning with Kernels - support vector machines, regularization, optimization and beyond, The MIT Press, Cambridge, Massachusetts, London, England, 2002.

***References :***

1. John Shawe-Taylor and Nello Cristianini, Kernel Methods for Pattern Analysis, Cambridge University Press, 2004.
2. Nello Cristianini and John Shawe-Taylor , Introduction to Support Vector Machines, Cambridge University Press, 2000.

**CS423** **COMPUTATIONAL TOPOLOGY** **3-0-0-6**

***Syllabus :*** This course is a combination of Algorithms, Geometry, and Topology. The course starts with a broad introduction to basic notions in Topology for a Computer Scientist. Then it primarily focuses on designing efficient Algorithms and data structures for the problems from Topology. The relevant topics ranging from point set topology to algebraic topology are presented. The course is motivated with the applications from computational structural biology, geometric modeling, meshing, curve and surface reconstruction, clustering, 3d-printing, orthodontics, and VLSI routing.

Introduction to topological spaces with motivating examples; Geometric topology: searching a triangulation, surface simplification, triangulations, and complexes; Manifolds: homeomorphism, Jordan separation Theorem, Conway's ZIP proof, imbedding graphs in the plane, and Euler characteristics; Homotopy: deformation retraction, topological equivalence, categories, functors, homotopic paths in the plane, and homotopy of curves on surfaces; Topological Graph Theory: Connected components in surface graphs, min-cuts in surface graphs, and tree decomposition; designing algorithms based on Homology and Duality Theories.

***Texts:***

1. Computational Topology by Herbert Edelsbrunner, First Edition, American Mathematical Society, 2010.
2. Topology by James R. Munkres, Second Edition, Prentice Hall, 2000.

***References :***

1. Algebra by Artin, Second Edition, Addison Wesley, 2010.
2. Introduction to Topology by Bert Mendelson, Third Edition, Dover Publications Inc., 1990.
3. Basic Topology by M. A. Armstrong, Springer, 2010.
4. Algebraic Topology by Allen Hatcher, First Edition, Cambridge University Press, 2001.
5. An Introduction to Morse Theory by Y. Matsumoto, First Edition, American Mathematical Society, 2001.

**CS425** **ADVANCED COMPUTER ARCHITECTURE** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Pipeline processor principles and design, Instruction set architecture; Memory addressing; Instruction composition; Instruction-level parallelism; Hazards: dynamic scheduling, branch prediction; Memory hierarchy; Processor case studies; Multiprocessor introduction: Shared-memory architectures and their synchronisation and consistency issues, Advanced multi-core topics; Transactional Memory; Interconnection networks.

***Texts :***

1. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, fourth edition, 2006.
2. David Culler, J.P. Singh and Anoop Gupta, Parallel Computer Architecture: A Hardware/Software Approach, Morgan Kaufmann, first edition, 1998.
3. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill, first edition, 1992.

***References :***

**CS427 FORMAL METHODS FOR SYSTEM VERIFICATION 3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Introduction to formal methods and hardware verification. Review of logics: Propositional Calculus and Predicate Calculus. Axioms and rules of Floyd-Hoare Logic. Application of Floyd-Hoare logic to verify hardware circuits. Describing hardware directly in higher order logic. Combinational and sequential behaviour of circuits. Specification of hardware systems. Introduction to Binary Decision Diagram (BDD) and modelling hardware with BDDs. Algorithms for BDD operations. Concept of OBDDs and ROBDDs and operation on ROBDDs. Introduction to Temporal Logic. Linear and Branching time temporal logic. Expressing properties in CTL and CTL*. CTL model checking algorithm. State space explosion problem: Symbolic data structure and symbolic model checking algorithms. Concept of on-the-fly model checking and automata-theoretic model checking. Study of verification tools: SMV and PVS.

***Texts :***

***References :***

1. M. Huth and M. Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, 2nd Ed, Cambridge University Press, 2004.

2. T. F. Melham, Higher Order Logic and Hardware Verification, Cambridge University Press, 1993.
3. E. M. Clarke, O. Grumberg and D. Peled, Model Checking, MIT Press, 1999.
4. K. L. McMillan, Symbolic Model Checking, Kluwer Academic Publisher, 1993.
5. Z. Manna and A. Pnueli, The Temporal Logic of Reactive and Concurrent System Specification, Springer-Verlag, 1992.

**CS429** **SEMANTICS OF PROGRAMMING LANGUAGES** **3-0-0-6**

*Pre-requisites :* CS201

***Syllabus :*** Overview of programming language constructs like procedures, jumps, non-determinism, continuations. Introduction to semantic systems. Operational semantics: Labelled transition systems, semantics of a simple language. Denotational semantics: lambda-calculus, semantics of a simple language with loops. Axiomatic semantics: Hoare logic, semantics of a subset of Pascal. Reasoning about concurrent features in programming languages using modal logic.

***Texts :***

1. G. Winskel, Formal Semantics of Programming Languages: An Introduction, MIT Press, Cambridge, 1993.

***References :***

1. M. J. C. Gordon, The Denotational description of programming languages: An Introduction, Springer-Verlag, 1979.
2. D. Gries, Science of Programming, Springer-Verlag, 1981.
3. D. Friedman, M. Wand and C. Haynes, Essentials of programming languages, 2nd Ed, MIT Press, 2001.
4. J. R. Hindley and H. P. Seldin, Introduction to Combinators and Lambda-calculus, Cambridge University Press, 1988.

**CS431** **FUNCTIONAL AND LOGIC PROGRAMMING** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Functional programming: Functions as first class objects, laziness, data-types and pattern matching, classes and overloading, side-effects etc. Languages like ML and Haskell will be used to describe the concepts. Lambda calculus: Syntax, conversions, normal forms, Church-Rosser theorem, combinators. Implementation issues: Graph reduction, Three Instruction Machine. Logic programming: Horn clauses, resolution, SLD-refutation, Prolog. Negation in logic programs and implementation issues.

***Texts :***

1. R. Bird and P. Wadler, Introduction to Functional Programming, 2nd Ed, Prentice-Hall, 1998.
2. S. L. Peyton-Jones, The Implementation of Functional Programming Languages, Prentice-hall, 1987.
(Full text available online: http://research.microsoft.com/Users/simonpj/Papers/slpj-book-1987/index.htm)

3. J. W. Lloyd, Foundations of Logic Programming, Springer-Verlag, 2nd Ed. 1987.

***References :***

1. J. D. Ullman, Elements of ML Programming, ML 97 Edition, 2nd Ed, Prentice-Hall, 1998.
2. L. Sterling and E. Shapiro, The Art of Prolog, 2nd Ed, MIT Press, 1994.
3. J. R. Hindley and H. P. Seldin, Introduction to Combinators and Lambda-calculus, Cambridge University Press, 1988.

**CS433** **ADVANCED COMPILERS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Introduction to code optimization, efficient code generation and parallelizing compilers. Data-flow analysis: Classical theory, bi-directional flows, unified algorithms etc. Efficient code generation: Algorithms, register allocation heuristics and automated tools. Parallelism detection: Data dependence, control dependence, various restructuring transformations on loops. Inter-procedural analysis: Constant propagation, data dependence etc. Selected case studies.

***Texts :***

1. S. Muchnick, Advanced Compiler Design and Implementation, Morgan Kaufmann, 1997.
2. M. J. Wolfe, High Performance Compilers for Parallel Computing, Addison-Wesley, 1995.

***References :***

1. V. Sarkar, Partitioning and Scheduling Parallel Programs for Multiprocessors, MIT Press, 1989.
2. A. Aho, R. Sethi and J. D. Ullman, Compilers: Principles, Techniques and Tools, Addison Wesley, 1986.
3. Selected research papers.

**CS418** **ADVANCED OPERATING SYSTEMS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Study of major Operating System issues such as Memory Management, Process Management and Scheduling, File Systems, Networking by looking at the internals of actual systems such as Unix, Linux, NT etc. Issues in design of distributed operating systems. Selected case studies such as Amoeba, Chorus, Mach etc

***Texts :***

***References :***

1. B. Goodheart and J. Cox, The Magic Garden Explained: The Internals of Unix System V Release 4, Prentice Hall 1994.
2. M. K. McKusick et al., The Design and Implementation of the 4.4 BSD Operating System, Addison Wesley, 1996.
3. U. Vahalia, Unix Internals: The New Frontiers, Prentice Hall, 1996.
4. P. K. Sinha, Distributed Operating Systems, Wiley-IEEE Press, 1996.
5. H. Custer, Inside Windows NT, 2nd Ed, Microsoft Press, 1998.
6. Selected papers and reports and source code.

**CS435** **DISTRIBUTED SYSTEMS** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus:*** Introduction to distributed computing models. Issues in distribution of data and control: Clock synchronization, agreement, deadlock detection, termination detection etc. Distributed file servers: Concurrency control and recovery, resiliency etc. Distributed programming environments: Communication primitives, selected case studies. (Note: Some topics may be added/deleted to suit specific offerings of the course)

***Texts :***

1. G. F. Coulouris, J. Dollimore and T. Kindberg, Distributed Systems: Concepts and Design, 4th Ed, Addison-Wesley, 2005.

***References :***

1. S. Mullender (Ed), Distributed Systems, 2nd Ed, Addison-Wesley, 1994.
2. M. Singhal and N. Shivratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.
3. Selected research papers.

**CS420** **INFORMATION TRANSMISSION AND SECURITY** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus*** *:* Information theory Fundamentals: Error Correcting Codes: Mathematical Preliminaries; Linear Block Codes; Cyclic Codes; BCH Codes; Arithmetic Codes; Convolutional Codes; Unidirectional Error Correcting Codes; Applications of Error Correcting Codes. Cryptography: Cryptographic techniques; Mathematical Preliminaries; Symmetric Key cryptography; Block Cipher and Stream Cipher; Public Key Cryptography; Attacks; Message Authentication: Digital signatures, MD5, SHA etc.; Key Exchange Schemes; E-cash/Money. Data Compression: Compression Techniques; Mathematical Preliminaries; Hoffman Coding; Arithmetic Coding; Dictionary Techniques; Static Dictionary, Adaptive Dictionary; Lossless Image Compression; Scalar and Vector Quantization; Differential Encoding; MPEG; JPEG; Video Compression

***Texts :***

1. T. R. N. Rao and E. Fujiwara, Error Control Coding for Computer Systems, Englewood Cliffs, NJ: Prentice Hall, 1989.
2. B. Schneier, Applied Cryptography, 2nd Ed, John Willey and Sons, 1996.
3. K. Sayood, Introduction to Data Compression, 2nd Ed, Morgan Kaufmann, 2000.

***References :***

1. M. Y. Rhee, Cryptography and Secure Data Communications, McGraw Hill, 1994.
2. S. Lin and D. J. Costello, Error Control Coding, 2nd Ed, Prentice Hall, 2005.
3. S. B. Wicker, Error Control systems for Digital Communication System and Storage, Prentice Hall, 1995.
4. T. C. Bell, J. G. Cleary and I. H. Witten, Text Compression, Advanced Reference Series, Englewood Cliffs, NJ: Prentice Hall, 1990.
5. R. M. Gray, Entropy and Information Theory, New York: Springer-Verlag, 1990.

(Full text available at http://www-ee.stanford.edu/~gray/it.pdf)

**CS422** **TOPICS IN NETWORKS** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Use of computer networks, network hardware and software; Layering, reference models and their comparison.Theoretical basis for data communication, transmission media and impairments, switching systems.Design issues, framing, error detection and correction, elementary and sliding window protocols, examples of data link layer protocols. Channel allocation problem, multiple access protocols, Ethernet, data link layer switching. Design issues, routing algorithms, congestion control, QOS, internetworking, IP and IP addressing.Transport service, elements of transport protocols, TCP and UDP. Email, DNS, Telnet, SSH, http, FTP.

***Texts*** *:*

1. 1. Tanenbaum, A.S, "Computer Networks", 4th Ed., Pearson Education. 2003.

2. Forouzan, B.A., "Data Communication and Networking", 4th Ed., Tata McGraw-Hill.2006.

***References*** *:*

1. Stallings W., "Data and Computer Communication", 8th Ed., Prentice-Hall.2007

2. Kurose, J.F. and Ross, K.W., "Computer Networking: A Top-Down Approach Featuring the Internet", 3rd Ed., Addison Wesley.2004

3. Comer, D.E. and Droms, R.E., "Computer Networks and Internets", 4th Ed., Prentice-Hall.

**CS424** **WEB DEVELOPMENT TECHNOLOGIES** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus :*** Introduction to the world wide web - servers, clients, browsers editors and languages; web technologies like HTML, Java, Javascript, Perl, CGI; web databases. The course will involve programming assignments and research projects using HTML, Java, Perl etc.

***Texts :***

***References :***

1. K. Arnold, J. Gosling and D. Holmes, The Java Programming Language, 3rd Ed, Addison Wesley, 2000.
2. P. Deitel and H. Deitel, Java - How to Program, 6th Ed, Prentice-Hall, 2005.
3. B. Breedlove, Web Programming Unleashed, Sams Net Publishing, 1996.
4. C. Musciano and B. Kennedy, HTML: The Definitive Guide, 2nd Ed, O'Reilly, May 1997.
5. L. Wall, T. Christiansen and R. L. Schwartz, Programming Perl, O'Reilly, 1996; also published by Shroff Publishers and Distributors Pvt. Ltd.

6. S. Gundavaram, CGI Programming on the World Wide Web, O'Reilly, March 1996.
7. D. Flanagan, Java in a Nutshell, O'Reilly, 1997 (also published by Shroff Publishers and Distributors Pvt. Ltd., Mumbai)
8. Other references and whitepapers on Java, HTML etc.

**CS426** **Big Data**
**3-0-0-6**

Introduction to Big Data Analytics - Big Data Overview, State of the Practice in Analytics, The Data Scientist, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle, Review of the Basic Data Analytic Methods using R, Introduction to R – look at the data, Analyzing and Exploring the Data, Statistics for Model Building and evaluation. Advanced Analytics - K-means clustering, Association rules, Linear Regression, Logistic Regression, Naïve Bayes, Decision Trees, Time Series Analysis, Text Analysis, Analytics for Unstructured Data (MapReduce and Hadoop), The Hadoop Ecosystem, In-database Analytics – SQL Essentials, Advanced SQL and MADlib for in-database.

***Texts***

1. "Big Data" by Viktor Mayer-Schönberger, Kenneth Cukier, ISBN:978- 0544002692, Eamon Dolan/Houghton Mifflin Harcourt 2013

2. "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence" by Pramod J. Sadalage, Martin Fowler, ISBN:978- 0321826626, Addison-Wesley, 2012

***References:***

1. “Hadoop Operation”, by Eric Sammer, ISBN: 978-1449327057, O’Reilly 2012

2. “MapReduce Design Patterns: Building Effective Algorithms and Analytics for Hadoop and Other Systems”, by Donald Miner, Adam Shook, ISBN: 978-1449327170, O’Reilly 2012

3. “Big Data Now”, by O’Reilly Media Inc., ASIN: B0097E4EBQ, O’Reilly 2012

**CS428** **WIRELESS NETWORKS** **3-0-0-6**

*Pre-requisites :* Nil

*Syllabus :* Introduction to wireless communication systems and networks; Wireless technologies: Cellular wireless networks and systems principles. Antennas and radio propagation. Signal encoding and modulation techniques. Spread spectrum. Coding and error control. Wireless Networking: Multiple access techniques. Mobile IP and WAP. Wireless systems and standards. Wireless LANs: Wireless LAN technology. Wireless standard (IEEE 802.11 etc.). Ad-hoc Networks. Bluetooth

***Texts :***

1. W. Stallings, "Wireless Communications and Networks", Pearson Education, 2002.

***References :***

1. T S Rappaport, "Wireless Communications: Principles & Practice", Second Edition, Pearson Education, 2002.
2. J Schiller, "Mobile Communications", Addison Wesley, 2000.
3. V K Garg, "IS-95 CDMA and CDMA2000", Prentice Hall PTR, 2000.
4. Research papers.

**CS437** **INTERNET PROTOCOLS** **3-0-0-6**

*Pre-requisites :* CS301

*Syllabus :* Overview of IPv4, TCP, IPv6, ICMP, ARP, DHCP; Routing Protocols: OSPF, RIP, BGP, Ad hoc network routing (AODV, DSR); IP Security: NAT, IPSEC, Socks, SSL; Quality of Service related protocols: Intserv, diffserv, Queuing techniques (WFQ, RED, etc.); Multi-Protocol Label Switching (MPLS) and GMPLS; Virtual Private Network (VPN) Protocols: L2TP, PPTP; Overview of Application Layer Protocols: DNS, LDAP, SMTP, POP3, IMAP4, SNMP; Voice over IP Protocols (VOIP) and videoconferencing: SIP, H323. Server Load Balancing Techniques.

***Texts :***

1. Adolfo Rodriguez, et. al, TCP/IP Tutorial and Technical Overview, IBM Redbook, available online at http://www.redbooks.ibm.com/pubs/pdfs/redbooks/gg243376.pdf, 2001.

***References :***

1. Charles. M.Kozierek, TCP/IP Guide, Shroff Publishers, Mumbai, 2005.
2. Uyless Black, MPLS and Label Switching Networks, Pearson Education (LPE), 2002.
3. Request for Comments (RFC) from www.ietf.org.

**CS439** **WIRELESS SENSOR NETWORK** **3-0-0-6**

*Pre-requisites :*

*Syllabus :* Introduction to ad hoc networks. Routing- Proactive routing protocols, Reactive routing protocols, backbone, Position based routing, power efficient routing; Introduction to sensor networks and its applications: Architecture and factors influencing the sensor network design. Routing protocols- data centric routing protocols, hierarchical routing protocols, location based routing, energy efficient routing etc; Node Scheduling and coverage issues, topology control. Querying, data collection and processing, Collaborative information processing and group connectivity. Target tracking and identity management using sensor networks. Localization . Application & future research Challenges.

***Texts :***

1. Wireless Sensor Networks : A systems perspective By Nirupama Bulusu and Sanjay Jha, editors Artech House, August 2005.
2. F. Zhao and L. Guibas. Wireless Sensor Networks: An Information Processing Approach. Elsevier/Morgan-Kaufmann, 2004.
3. Wireless Sensor Networks : Architecture and Protocols By Jr., Edgar H. Callaway.
4. Wireless Sensor Networks, An Edited Book Editors : C.S Raghavendra, Krishna M. Sivalingam and Taieb Znati.

***References :***

**CS432** **ENTERPRISE SYSTEMS** **3-0-0-6**

*Pre-requisites :*

*Syllabus :* Overview of Database Management Systems. Overview of Model - View - Control (MVC) method of software development in a 3 tier environment. Tools and Technologies - Brief overview of the following : Java server pages and related Java Technologies, Microsoft .NET framework, PHP, Ruby on Rails, Javascript, Ajax. Service Oriented Architecture (SOA) - Principles of loose coupling, encapsulation, inter-operatibility; Web Services as the implementation vehicle protocols, usage. Enterprise Resource Planning (ERP) systems and their architecture; overview of SAP and Oracle Applications - Generic ERP Modules : Finance, HR, Materials Management, Investment, etc; Examples of Domain Specific Modules; Electronic Data Exchange; Customer Relationship Management (CRM); Supplier Relationship Management (SRM). Security Issues - Authentication, authorisation, access control; roles; single-sign-on, directory servers; audit trails; digital signatures; Encryption: review of IPSec, SSL and other technologies; Overview of : MPLS, Virtual Private Networks (VPN), firewalls, network monitoring and enforcement of policies. Software Acquisition Process - tendering; conditions of contract; commercial off the shelf software (COTS) versus Bespoke Implementations; total cost of ownership; Issues on using Open source software or free software or licensed software. Hardware Architectures for Enterprise Systems - Servers, clustering, storage area networks, storage units, back-up strategies; Local Area Network (LAN) technologies and products; Data Centres; Disaster recovery site design and implementation issues; Hardware Acquisition Issues.

***Texts :***

***References :***

1. Material as available on the Internet. Wikipedia Articles will be the starting point for many of the topics.
2. Material in the web sites of some the leading vendors.

* www.oracle.com/technology
* www.sap.com, www.sdn.sap.com
* www.ibm.com, www.redbooks.ibm.com
* www.sun.com,, java.sun.com/developer/
* www.cisco.com, www.hp.com

**CS434 PERFORMANCES MODELLING OF COMMUNICATION AND COMPUTER SYSTEMS 3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Modelling philosophy and Principles: Discussion of several techniques of modelling; Introduction to Queuing theory and Markov chains: Queuing theory applied to study single and multiple server systems, statistical equilibrium, stationary processes, and ergodic processes; Monte Carlo simulation: Build simulation models from first principles, Discussion of the technique and theory of simulation, Start the simulation model as lab work; Mean Value analysis applied to multiprocessor systems; Workload Characterization: System dependent characterization, System independent characterization; Lagrangian and Eulerian views of job flow in systems; Communication Networks: Relation between bandwidth and latency; Sizing of Systems; Capacity Planning of systems; Software performance and Tuning; Software and Hardware monitors; Controlled experiments: Benchmarking and extrapolation of results to uncontrolled environment; Cloud Computing systems: performance framework.

***Texts :***

***References :***

1. Kai Hwang, Advanced Computer Architecture, McGraw Hill,Computer Science Series, 1993.
2. Krishna Kant, Introduction to Computer System Performance Evaluation, McGraw Hill International Science series, 1992.
3. Gunter Bolch, Stefan Greimer, Herman de Meer,and Kishore S. Trivedi, Queuing Networks and Markov Chains, John Wiley, Interscience, 1998.
4. Jean Walrand, Kallol Bagchi and George W. Zobrist, editors, Network Performance Modeling and Simulation, Gordon and Breach Science Publishers, 1998.
5. Domenico Ferrari, Computer Systems Performance Evaluation, Prentice Hall, 1978.
6. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, fourth edition, 2006.
. Peter G. Harrison, Naresh M. Patel, Performance Modeling of Communication Networks and Computer Architectures, Addison Wesley Longman Publishing Co, 1992.

**CS436 ARTIFICIAL INTELLIGENCE 3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction to intelligent agents. Problem Solving: Searching, Intelligent search methods, Game Playing. Knowledge and Reasoning: Building a Knowledge Base. Inference in First Order Logic, Logical reasoning systems. Planning. Uncertain Knowledge and Reasoning, Probabilistic Reasoning Systems. Learning from Observations: Inductive Learning, Learning Decision Trees, Computational Learning Theory, Explanation Based Learning. Genetic algorithms, Artificial Neural Networks and Fuzzy Approaches. Introduction to Natural Language Processing. The course will include programming projects involving programming in Lisp, Prolog and C++.

***Texts :***

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003.

***References :***

1. E. Rich and K. Knight, Artificial Intelligence, McGraw Hill, 1991.
2. P. H. Winston and B. K. P. Horn, Lisp, 3rd Ed, Addison-Wesley, 1989.
3. P. Norvig, Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp, Morgan Kauffman, 1991.
4. I. Bratko, Prolog Programming for Artificial Intelligence, 3rd Ed, Addison-Wesley, 2001.

**CS441** **MACHINE LEARNING** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Definitions, goals and history of Machine Learning. Taxonomies of methods and research paradigms. Knowledge-level vs. symbol-level learning. Major approaches of learning: Inductive concept acquisition (version-space, ID3, and AQ algorithms); inductive bias, minimum description length principle. Formal models of learnability. learning in the limit. PAC learnability. Ockham's razor. Learning by observation and discovery (e.g., conceptual clustering in CLUSTER and COBWEB) Scientific and mathematical discovery (e.g., AM and BACON) Explanation-based learning: macro-operators (STRIPS), explanation generalization (as in EBG, EGGS, and SOAR); Connectionist (i.e. neural network) learning (perception and back-propagation), Analogy and case-based reasoning (exemplars, structure mapping).

***Texts :***

1. J. Shavlik and T. Dietterich (Ed), Readings in Machine Learning, Morgan Kaufmann, 1990.
2. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.

***References :***

**CS436** **PRINCIPLES OF ROBOTICS** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction to robot manipulation. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control. Task planning with emphasis on computational geometry methods for robot path finding,robot arm reachability, grasp planning etc. Overview of robot vision.

***Texts :***

1. R. J. Schilling, Fundamentals of Robotics: Analysis and Control, Prentice-Hall India 1996.

***References :***

1. K. S. Fu, R. C. Gonzalez and C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987.

2. R. P. Paul, Robot Manipulators: Mathematics, Programming and Control, MIT Press, 1981.
3. J. C. Latombe, Robot Motion Planning, Kluwer Academic Publishers, 1991.

**CS440 INTELLIGENT SYSTEMS AND INTERFACES 3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Language Processing: Computational Phonology: Issues, Phonological rules, Mapping text to phones, Prosody in TTS, Probabilistic models of pronunciation and Spelling, N-Grams. Syntax: Word classes and POS tagging, CFG for English, Lexicalized and Probabilistic Parsing. Semantics: Semantic representation, Semantic and Lexical analysis and Word sense disambiguation, IR. Pragmatics: Discourse, Dialogue agents, Natural Language Generation and Machine translation. Machine Learning: Data Mining: Association rules, Clustering, Decision Trees. Text Mining. Synergetic techniques: Genetic algorithms and ANN techniques for machine learning. Applications to bioinformatics. Intelligent Interfaces: Incorporating Intelligence: Requirements, design issues. Applications: Development of Intelligent interfaces for systems - Stand-alone systems like OS, Databases, Physical machines including robots. Web based applications like Tutoring systems, Web Mining, e-shopping.

***Texts :***

***References :***

1. D. Jurafsky and J. H. Martin, Speech and language Processing, Pearson Education, 2000.
2. E. Reiter and R. Dale, Building Natural Language Generation Systems, Cambridge University Press, 2000.
3. T. M. Mitchell, Machine learning, McGraw-Hill 1997.
4. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000.

**CS442 PATTERN RECOGNITION 3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction to Pattern Recognition: Learning paradigms, Supervised and unsupervised learning; Bayesian decision theory: Minimum error rate classifier; Parameter estimation: Maximum likelihood and Bayesian Estimation; Hidden Markov models; Nonparametric techniques: Nearest neighbor rules, Parzen windows; Decision trees: Axis-parallel, Oblique, Impurity measures; Feature selection: Forward, backward search; Component analysis and discriminant functions: Principal component analysis, Fisher linear discriminant, Perceptron, Support vector machines; Generalization ability of learning methods: Bias and variance, Regularization; Bootstrapping, Boosting, Bagging; Unsupervised learning and clustering: k-Means methods.

***Texts :***

1. R. O. Duda, P. E. Hart and D. G. Stork, Pattern classification, John Wiley & Sons, 2002.

***References :***

1. C. M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. V. N. Vapnik, The Nature of Statistical Learning Theory, Springer, 2000.

3. N. Cristianini and J. Shawe-Taylor, An Introduction to Support Vector Machines, Cambridge University Press, 2000.
4. Selected Research Papers.

**CS443** **DATA MINING** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Types of data mining problems. The process of data mining. Statistical evaluation of big data: statistical prediction, performance measures, pitfalls in data-mining evaluation. Data preparation: data models, data transformations, handling of missing data, time-dependent data, textual data. Data reduction: feature selection, principal components, smoothing data, case subsampling. Predictive modeling: mathematical models, linear models, neural nets, advanced statistical models, distance solutions, logic solutions, decision trees, decision rules, model combination. Solution analyses: graphical trend analyses, comparison of methods. Case studies. Future trends: text mining, visualization, distributed data. Practical sessions using open-source software.

***Texts :***

1. S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998.

***References :***

1. S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004.

**CS445** **MULTIMEDIA SYSTEMS** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Introduction to Multimedia, DSP Preliminaries: Fundamentals of Signal and Systems, Transformations, Image Representations and Transformations, Elements of Image Compression and Coding: Lossy and Lossless Image Compressions, Fixed-length and Variable-length Coding, Discrete Cosine Transforms and Coding, Wavelet Transform and Coding, Multimedia Standards: Still Image Compression Standards: JPEG and JPEG 2000, Elements of Video Compression System: DPCM, Motion Estimation, Video Compression Standards: Overview, H.261, H.263, H.264, MPEG-1: Specification, continuity and synchronization, MPEG-2: Overview, scalability, Audio Compression: Overview, MPEG Audio Coder

***Texts :***

1. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Multimedia Communication Systems: Techniques, Standards, and Networks, Prentice Hall PTR, 2000.
2. Yun Q Shi,, Huifang Sun, Image and Video Compression for Multimedia Engineering: Fundamentals, Algorithms, and Standards, second edition, CRC Press, 2008.

***References :***

1. John G. Proakis and Dimitris K Manolakis, Digital Signal Processing (4th Edition), Prentice Hall, 2006.
2. Iain Richardson, Iain E. G. Richardson, " H.264 and MPEG-4 Video Compression: Video Coding for Next Generation Multimedia,"John Willey 2004.
3. A. K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall, 1989.

4. Oge Marques, Practical Image and Video Processing Using MATLAB, Wiley-IEEE Pres, 2009.
5. Andreas Spanias, Ted Painter, Venkatraman Atti, Audio Signal Processing and Coding, John Wiely, 2007.
6. W. Pennebaker, J. Mitchell, "JPEG Still Image Data Compression Standard", Van Nostrand Reinhold, New York, 1993.
Visit Amazon's Dzung Tien Hoang Pagesearch results. Learn about Author Central Jeffrey Scott Vitter, Jeffrey S Vitter, Dzung Tien Hoang Efficient Algorithms for MPEG Video Compression, John Wiley & Sons, 2002.

**CS444** **FUNDAMENTALS OF INFORMATION RETRIEVAL** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** This course is intended for both undergraduate and postgraduate students. The domain of Information Retrieval (IR) is concerned with the extraction of relevant information from large collections of documents. It has applications to proprietary retrieval systems as well as the WWW, Digital Libraries and commercial recommendation systems. The objective of the course is to introduce students to the theoretical underpinnings of IR and practical experience in the construction of IR systems through a series of programming assignments.
Introduction: concepts and terminology of information retrieval systems, Information Retrieval Vs Information Extraction; Indexing: inverted files, encoding, Zipf's Law, compression, boolean queries; Fundamental IR models: Boolean, Vector Space, probabilistic, TFIDF, Okapi, language modeling, latent semantic indexing, query processing and refinement techniques; Performance Evaluation: precision, recall, F-measure; Classification: Rocchio, Naive Bayes, k-nearest neighbors, support vector machine; Clustering: partitioning methods, k-means clustering, hierarchical; Introduction to advanced topics: search, relevance feedback, ranking, query expansion.

***Texts :***

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schtze, Introduction to Information Retrieval, Cambridge University Press. 2008
2. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Modern Information Retrieval, Addison Wesley, 1st edition, 1999.

***References :***

1. Soumen Chakrabarti, Mining the Web, Morgan-Kaufmann Publishers, 2002.
2. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Springer, Corr. 2nd printing edition, 2009.
3. David A. Grossman, Ophir Frieder, Information Retrieval: Algorithms and Heuristics, Springer, 2nd edition, 2004.
4. William B. Frakes, Ricardo Baeza-Yates, Information Retrieval Data Structures and Algorithms, Prentice Hall, 1992.
5. G. Salton, M. J. McGill, Introduction to Modern Information Retrieval, McGraw-Hill, 1986.
6. C. J. Van Rijsbergen, Information Retrieval, Butterworth-Heinemann; 2nd edition, 1979.

**CS447** **HUMAN COMPUTER INTERACTION** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** HCI foundation: history, human abilities, state of the art in computing technology, interaction styles and paradigms; Design process: interaction design basics, HCI in software process, design rules and guidelines, implementation support (UI software), universal design; Interaction styles: direct manipulation, WIMP, web interface, natural

language interaction; Evaluation techniques; Models in HCI: formal models, linguistic models, cognitive models (KLM/GOMS), cognitive architectures, hybrid models; Task analysis; Dialogue design; Advanced topics (overview) pervasive computing, CSCW, virtual reality, tangible user interface, multimedia.

***Texts :***

1. A. Dix, J. Finlay, G. D. Abowd and R. Beale, Human Computer Interaction, 3rd edition, Pearson Education, 2005.

***References :***

1. J. Preece, Y. Rogers, H. Sharp, D. Baniyon, S. Holland and T. Carey, Human Computer Interaction, Addison-Wesley, 1994.
2. C. Stephanidis (ed.), User Interface for All: Concepts, Methods and Tools. Lawrence Erlbaum Associates, 2001.
3. J. M. Caroll (ed.), HCI Models, Theories and Frameworks: Towards a Multidisciplinary Science (Interactive Technologies), Morgan Kauffman, 2003.
4. W. O Galitz, The Essential Guide to User Interface Design, John Wiley & Sons, Inc, 2002 (Indian Edition).
5. B. Shneiderman, Designing the User Interface, Addison Wesley, 2000 (Indian Reprint).

**CS449** **COMPUTATIONAL SYSTEMS BIOLOGY** **3-0-0-6**

*Pre-requisites :*

***Syllabus :*** Cellular components interact with each other to carry out their specific functions. One way to understand cellular processes at system level is to model them as networks of interactions. The Objective of the course is to understand underlying computational challenges posed by such models. Algebraic graph theory, machine learning and statistics have been widely used for inference and analysis of such networks. This course aims to discuss state-of-the-art algorithms, demonstrate their use in understanding molecular mechanism at systems levels along with limitations. The course would not require any biological background and all relevant biological concepts would be introduced in the course.

Introduction: Molecular Cell Biology, Systems Biology, Networks; Biological Networks: Transcriptional Regulatory Networks, Protein-protein interaction networks, Metabolic Networks, Genetic Networks, Disease Networks; Networks Measures; Inference of Networks: Graphical Models, Kernel based method, Regression based method, Information Theory based models; Network Analysis: Generic organizing principles of biological networks; Network integration; Application of networks in disease diagnosis and drug target prediction. Application of model verification and formal methods.

***Texts :***

1. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, and Ralf Herwig. Systems Biology: A Textbook, Wiley-Blackwell, 2009.

***References :***

1. Uri Alon. An Introduction to Systems Biology - Design Principles of Biological Circuits, CRC Press, 2007.
2. Mark E. J. Newman. Networks: An Introduction, Mark Newman, Oxford University Press, 2010.
3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell, Garland Science (Taylor & Francis Group), 2007.

**CS453** **MOBILE ROBOTICS** **3-0-0-6**

*Pre-requisites :* Nil

*Syllabus :* Introduction to Mobile robot architectures, Control Paradigms, Sensors and actuators. Learning Approaches for robots. Navigation Strategies, Detecting and handling Novelty. Behavior-based robotics, AlE and their application to robots. Case studies of learning robots, Laboratory sessions will include study and implementations of the above methodologies using real robots.

***Texts :***

1. U. Nehmzow, Mobile Robotics - A Practical Introduction, 2nd Ed, Springer, 2003.
2. L. N. de Castro and J. Timmis, Artificial Immune Systems: A New Computational Intelligence Approach, Springer, 2002.
3. D. Dasgupta, Artificial Immune Systems and Their Applications, Springer, 1999.
4. R. C. Arkin, Behaviour Based Robotics, MlT Press, 1998.

***References :***

**CS 446** **Digital Watermarking** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus:*** Digital Watermarking Fundamentals - Spatial-Domain Watermarking, Substitution Watermarking in the Spatial Domain, Additive Watermarking in the Spatial Domain, Frequency-Domain Watermarking, Substitution Watermarking in the Frequency Domain, Multiplicative Watermarking in the Frequency Domain, Watermarking Based on Vector Quantization, The Rounding Error Problem, The Fragile Watermark, The Block-Based Fragile Watermark, Weaknesses of the Block-Based Fragile Watermark, The Hierarchical Block-Based Fragile Watermark, The Robust Watermark, The Redundant Embedding Approach, The Spread Spectrum Approach. Watermarking Attacks and Tools - Image Processing Attacks, Attacks by Filtering, Attack by Remodulation, Attack by JPEG Coding Distortion, Attack by JPEG 2000 Compression, Geometric Transformation, Attack by Image Scaling, Attack by Rotation, Attack by Image Clipping, Attack by Linear Transformation, Attack by Bending, Attack by Warping, Attack by Perspective Projection, Attack by Collage, Attack by Template, Cryptographic Attach, Protocol Attacks, Watermarking Tools.

**Text/References**

1 Information Hiding (Steganography and Watermarking - Attacks and Countermeasures), Johnson, Neil F./ Duric, Zoran/ Jajodia, Sushil , luwer Academic Pub, 2001

2 Information Hiding Techniques for Steganography and Digital Watermarking ,Katzenbeisser, Stefan (Edt)/ Petitcolas, Fabien, A.P. (Edt) , Artech House, 2000

3 Intelligent Watermarking Techniques, J-S Pan, H-C Huang, L.C. Jain, World Scientific Pub. Co., 2004

4 Aliroo Home page, "www.aliroo.com

5 "ImageLock Home page", www.imagelock.com

6 "Digimarc Home page", www.digimarc.com

**CS 448** **Steganography** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus:*** Origins & Overview of Steganography - History of Use, Covert Messaging, Null Cipher Messages, Steganography vs. Encryption, Threats Posed by Steganography Use, Steganography in the Media, Availability & Production. Digital Carriers - Used to Exploit Human Weaknesses, Digital Images - Palette, True Color, Compressed Lossy, lossless, Formats: BMP, JPG, GIF, PNG, Digital Audio, Converters, Signal Processors, Wav files MP3, Dangers. Steganography Embedding Tools - Steganography Methods, Data Appending, Formatting Modification, Word Substitution, Color Palette Substitution, 24 Bit LSB Encoding, DCT Modification, PNS Modification, Covert Channels. Steganalysis - An Overview, The Statistical Properties of Images, The Visual Steganalytic System, IQM-Based Steganalytic System, Learning Strategies, Introduction of the Support Vector Machine, Neural Networks, Principle Component Analysis, Frequency-Domain Steganalytic System.

**Texts**

1 Information Hiding (Steganography and Watermarking - Attacks and Countermeasures), Johnson, Neil F./ Duric, Zoran/ Jajodia, Sushil , luwer Academic Pub, 2001

2 Information Hiding Techniques for Steganography and Digital Watermarking ,Katzenbeisser, Stefan (Edt)/ Petitcolas, Fabien, A.P. (Edt) , Artech House, 2000

3 Intelligent Watermarking Techniques, J-S Pan, H-C Huang, L.C. Jain, World Scientific Pub. Co., 2004

4 Aliroo Home page, "www.aliroo.com

5 "ImageLock Home page", www.imagelock.com

6 "Digimarc Home page", www.digimarc.com

**CS450** **Video Processing** **3-0-0-6**

***Syllabus:*** Basic Steps of Video Processing: Analog Video, Digital Video. Time-Varying Image Formation models: Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Video signals, Filtering operations. 2-D Motion Estimation: Optical flow, General Methodologies, Pixel Based Motion Estimation, Block- Matching Algorithm, Mesh based Motion Estimation, Global Motion Estimation, Region based Motion Estimation, Multi resolution motion estimation, Waveform based coding, Block based transform coding, Predictive coding, Application of motion estimation in Video coding.

**TEXTS:**

1. Digital Image Processing – Gonzaleze and Woods, 3rd Ed., Pearson.

2. Video Processing and Communication – Yao Wang, Joem Ostermann and Ya–quin Zhang. 1st

Ed., PH Int.

**REFRENCES:**

1. Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools – Scotte Umbaugh, 2nd Ed, CRC Press, 2011.

2. Digital Video Processing – M. Tekalp, Prentice Hall International.

3. Digital Image Processing – S.Jayaraman, S.Esakkirajan, T.Veera Kumar – TMH, 2009.

4. Multidimentional Signal, Image and Video Processing and Coding – John Woods, 2nd Ed, Elsevier.

5. Digital Image Processing with MATLAB and Labview – Vipula Singh, Elsevier.

6. Video Demystified – A Hand Book for the Digital Engineer – Keith Jack, 5th Ed., Elsevier.

**CS 451** **Digital Image Processing** **3-0-0-6**

*Pre-requisites :* Nil

***Syllabus:*** Introduction - Elements of digital image processing systems, Elements of visual perception, brightness, contrast, hue, saturation, machband effect, Color image fundamentals - RGB, HSI models, Image sampling, Quantization, dither, Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT, KLT, SVD. Image Enhancement - Histogram equalization and specification techniques, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contraharmonic mean filters, Homomorphic filtering, Color image enhancement. Image restoration - Degradation model, Unconstrained restoration - Lagrange multiplier and Constrained restoration, Inverse filtering-removal of blur caused by uniform linear motion, Wiener filtering, Geometric transformations-spatial transformations. Image segmentation - Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and Merging – Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm. Compression - Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Vector Quantization, Transform coding, JPEG standard, MPEG. Image. Morphology - Preliminaries, dilation, erosion, open and closing, hit or miss transformation, basic morphologic algorithms.

**Texts**

1. Digital Image Processing, Rafael C.Gonzalez, Richard E.Woods, Second Edition, Pearson Education/PHI, 2000.

2. . W.K.Pratt, Digital Image Processing ,3/e Edn., John Wiley & sons, Inc. 2006.

3. K. R. Castleman, Digital Image Processing, Pearson, 2006.

4. Anil K. Jain, Fundamental of image processing, Pearson, 2002.

**References**

1. Image Processing, Analysis, and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Second Edition, Thomson Learning, 2008.

2. Introduction to Digital Image Processing with Matlab, Alasdair McAndrew, Thomson Course Technology,2001.
3. Computer Vision and Image Processing, Adrian Low, Second Edition, B.S. Publications, 2005.
4. Digital Image Processing using Matlab, Rafael C.Gonzalez, Richard E.Woods, Steven L. Eddins, Pearson Education, 2007.

**CS452** **Natural Language Processing** **3-0-0-6**

Lexical Functional Grammar, Tree Adjoining Grammar, Government & Binding, Paninian Grammar. Comparison of Paninian Grammar with others. Logical Semantics, Script, Conceptual Dependency. Paragraph, Story, Dialogue understanding. Anaphora Resolution. Machine Translation with special reference to Indian Languages. Natural language interfaces to databases. Introduce more new research oriented topics, topics of current research which will focus on the state- of-the-art in various areas of Natural Language Processing.

**TEXTS:**

1. Grasz, Jones & Webber (Ed.): Readings in Natural Language Processing, Morgan Kaufmann, 1986.
2. Gazdar & Mellish: Natural Language Processing in PROLOG, Addision Wesley, 1989.
3. Leonard Bolc. (Ed.): Natural Language Parsing Systems, Springer Verlag, 1987.
4. McDonald & Bolc. (Ed.): Natural Language Generation Systems, Springer Verlag, 1987.
5. W. J. Hutchins: Machine Translation - Past, Present & Future, Ellis Horwood, 1986.
**6.** Bharati, Chaitanya and Sangal: Natural Language Processing- a Paninian perspective, PHI, 1985.

**CS454** **Cloud Computing** **3-0-0-6**

***Syllabus:*** Business and IT perspective, Cloud and virtualization, Cloud services requirements, cloud and dynamic infrastructure, cloud computing characteristics, cloud adoption. Cloud characteristics, Measured Service, Cloud models, security in a public cloud, public verses private clouds, cloud infrastructure self service. Gamut of cloud solutions, principal technologies, cloud strategy, cloud design and implementation using SOA, Conceptual cloud model, cloud service demand. Cloud ecosystem, cloud business process management, cloud service management, cloud stack, computing on demand, cloud sourcing. Cloud analytics, Testing under cloud, information security, virtual desktop infrastructure, Storage cloud. Resiliency, Provisioning, Asset management, cloud governance, high availability and disaster recovery, charging models, usage reporting, billing and metering. Virtualization defined, virtualization benefits, server virtualization, virtualization for x86 architecture, Hypervisor management software, Logical partitioning, VIO server, Virtual infrastructure requirements**.** Storage virtualization, storage area networks, network attached storage, cloud server virtualization, virtualized data center. SOA journey to infrastructure, SOA and cloud, SOA defined, SOA defined, SOA and IAAS, SOA based cloud infrastructure steps, SOA business and IT services.

**TEXTS:**

1. Cloud Computing by Dr. Kumar Saurabh, Wiley India, 2011.

**References**

1. Michael Miller, Cloud Computing: Web based applications that change the way you work and collaborate online, Que publishing , August 2009

2. Haley Beard, Cloud Computing Best Practices for Managing and Measuring Processes for On Demand computing applications and data Centers in the Cloud with SLAs, Emereo Pty Limited, July 2008.

**CS455 COMPUTER AND NETWORK SECURITY 3-0-0-6**

*Pre-requisites :*

***Syllabus:*** Overview, vulnerabilities, risk assessment, incidents. Cryptography: Classical Cryptography, Symmetric Cryptography, Public Key (Asymmetric cryptography), Modern Cryptography, Hash Functions, Key Exchange. Review: Installing Unix and common service daemons (Unix Security, Windows NT Security, Ping, traceroute, TCP Dump, sniffer etc.), Networking. Security issues: Terminology (Integrity, Availability, Confidentiality, Non-repudiation, Authentication, Authorization/Access Control, accounting, auditing, Passive and Active Attacker, Interruption, Interception, Modification, Fabrication, Social Engineering), Vulnerabilities and Counter Measures (Viruses, worms, Trojan horses, backdoors, unused services, buffer overflows, RPC), Exploits (Buffer overflow, Port Scanning etc). Applications Security (System Security, Audit Logs Intrusion Detection, Wrappers, Password and remote authorization tools e.g. PGP, S/MIME, SSH, Netscape/SSL, SET, IPsec, Kerberos, Firewalls, VPN etc, Secure (commerce) Transaction over a network, Network Anonymity.

***Texts :***

1. W. Stallings, Cryptography and Network Security: Principles and Practice, 3rd Ed, Prentice Hall, 2003.

***References :***

1. B. Schneier, Applied Cryptography, 2nd Ed, John Wiley & Sons, Inc., 1996.
2. A. Menezes, P. van Oorshot and S. Vanstone, Handbook of Applied Cryptogrphy, CRC Press, 1997.
3. C. Kauffman, R. Perham and M. Speciner, Network Security: Private Communication in a Public World, Prentice-Hall, 1994.
4. H. C. A. van Tilborg, Fundamentals of Cryptology, Kluwer Academic Publishers, 2000.
5. P. Garrett, Making and Breaking Codes: An Introduction to Cryptology, Prentice-Hall, 2001.
6. P. Wayner, Disappearing Cryptography, 2nd Ed, Morgan Kaufmann, 2002.
7. W. Cheswick, S. Bellovin and A. Rubin, Firewalls and Internet Security. Repelling the Wiley Hacker, 2nd Ed, Addison-Wesley, 2003.
8. Related publications in Journals/Conferences.