# B. Tech.

**IN**

# COMPUTER SCIENCE & ENGINEERING

## CURRICULUM AND SYLLABUS

**(Applicable from 2024 onwards)**


**Department of Computer Science & Engineering**
**NATIONAL INSTITUTE OF TECHNOLOGY MANIPUR**
**Langol Road, Lamphelpat, Imphal, Manipur - 795004**

**COURSE STRUCTURE OF B.Tech. in COMPUTER SCIENCE AND ENGINEERING**

| Sl. No. | Course Components | No. of Course | Credits |
|---|---|---|---|
| 1. | Basic Science Course (BSC) | 7 | 23 |
| 2. | Engineering Science Course (ESC) | 7 | 26 |
| 3. | Departmental Core Courses (DCC) | 17 | 69 |
| 4. | Departmental Elective Courses (DEC) | 5 | 15 |
| 5. | Open Elective Course (OEC) | 2 | 6 |
| 6. | Skill Enhancement Courses (SEC) | 2 | 6 |
| 7. | Ability Enhancement Mandatory Course (AEMC) | 4 | 13 |
| 8. | Value Addition Courses (VAC) | 6 | 2 |
| | **Total** | 50 | 160 |

**PROGRAMME STRUCTURE**
**Semester I**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CH 1101 | Engineering Chemistry | BSC-1 | 3 | 0 | 2 | 4 |
| 2. | ME1101 | Engineering Mechanics | ESC-1 | 3 | 1 | 0 | 4 |
| 3. | ME 1102 | Engineering Drawing | ESC-2 | 1 | 2 | 0 | 3 |
| 4. | MA 1101 | Engineering Mathematics-I | BSC-2 | 3 | 0 | 0 | 3 |
| 5. | PH 1101 | Engineering Physics-I | BSC-3 | 3 | 0 | 2 | 4 |
| 6. | HS 1101 | Communication Skills | SEC-1 | 3 | 0 | 0 | 3 |
| 7. | IC 1191 | Induction Programme* | VAC-1 | 0 | 0 | 0 | 0 |
| 8. | IC 1192 | Extra Academic Activity-I* | VAC-2 | 0 | 0 | 0 | 0 |
| | | **Total** | | 16 | 3 | 4 | 21 |

**Semester II**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS 1201 | Introduction to Computing | ESC-3 | 3 | 0 | 4 | 5 |
| 2. | EE 1201 | Basic Electrical Engineering | ESC-4 | 3 | 0 | 2 | 4 |
| 3. | MA 1201 | Engineering Mathematics-II | BSC-4 | 3 | 0 | 0 | 3 |
| 4. | EC 1201 | Basic Electronics Circuits | ESC-5 | 3 | 0 | 2 | 4 |
| 5. | CE 1201 | Environmental Engineering | ESC-6 | 3 | 0 | 0 | 3 |
| 6. | ME 1201 | Engineering Workshop | ESC-7 | 1 | 0 | 4 | 3 |
| 7. | IC 1291 | Extra Academic Activity-II* | VAC-3 | 0 | 0 | 0 | 0 |
| | | **Total** | | 16 | 0 | 12 | 22 |

*Value Addition Courses (VAC) will be floated by Department of Humanities and Social Science (HSS)

**Semester III**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MA2301 | Engineering Mathematics III | BSC-5 | 3 | 0 | 0 | 3 |
| 2. | CS2301 | Data Structures | DCC-1 | 3 | 0 | 3 | 4.5 |
| 3. | CS2302 | Discrete Structures | DCC-2 | 3 | 0 | 0 | 3 |
| 4. | CS2303 | Digital Logic Design | DCC-3 | 3 | 0 | 3 | 4.5 |
| 5. | HS2301 | Managerial Economics & Financial Accounting | SEC-2 | 3 | 0 | 0 | 3 |
| 6. | CS2304 | Programming in Python | DCC-4 | 3 | 0 | 2 | 4 |
| 7. | SA2391 | NCC/NSO | VAC-4 | 0 | 0 | 2 | 0 |
| | | **Total** | | **18** | **0** | **10** | **22** |

**Semester IV**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS2401 | Formal Languages and Automata Theory | DCC-5 | 3 | 1 | 0 | 4 |
| 2. | CS2402 | Design and Analysis of Algorithms | DCC-6 | 3 | 0 | 3 | 4.5 |
| 3. | CS2403 | Computer Organization and Architecture | DCC-7 | 3 | 0 | 2 | 4 |
| 4. | MA2401 | Probability and Random Processes | BSC-6 | 3 | 0 | 0 | 3 |
| 5. | CS2404 | Object Oriented Programming | DCC-8 | 3 | 0 | 3 | 4.5 |
| 6. | SA2491 | NCC/NSO | VAC-5 | 0 | 0 | 2 | 0 |
| | | **Total** | | **15** | **1** | **10** | **20** |

**Semester V**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MA3501 | Optimization Techniques | BSC-7 | 3 | 0 | 0 | 3 |
| 2. | CS3501 | Software Engineering | DCC-9 | 3 | 0 | 0 | 3 |
| 3. | CS3502 | Operating Systems | DCC-10 | 3 | 0 | 3 | 4.5 |
| 4. | CS3503 | Compiler Design | DCC-11 | 3 | 0 | 3 | 4.5 |
| 5. | CS3504 | Data Communication | DCC-12 | 3 | 0 | 0 | 3 |
| 6. | CS35XX | Department Elective - I | DEC-1 | 3 | 0 | 0 | 3 |
| | | **Total** | | **18** | **0** | **6** | **21** |

**Semester VI**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS3601 | Database Management Systems | DCC-13 | 3 | 0 | 3 | 4.5 |
| 2. | CS3602 | Computer Networks | DCC-14 | 3 | 0 | 3 | 4.5 |
| 3. | CS3603 | Artificial Intelligence | DCC-15 | 3 | 0 | 0 | 3 |
| 4. | CS36XX | Department Elective - II | DEC-2 | 3 | 0 | 0 | 3 |
| 5. | CS36XX | Department Elective - III | DEC-3 | 3 | 0 | 0 | 3 |
| 6. | CS3639 | Minor Project | AEMC-1 | 0 | 0 | 4 | 2 |
| | | **Total** | | 15 | 0 | 10 | 20 |

**Semester VII**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS4701 | Computer Graphics | DCC-16 | 3 | 0 | 3 | 4.5 |
| 2. | CS4702 | Machine Learning | DCC-17 | 3 | 0 | 3 | 4.5 |
| 3. | CS47XX | Department Elective - IV | DEC-4 | 3 | 0 | 0 | 3 |
| 4. | OEC | Open Elective Course - I | OEC-1 | 3 | 0 | 0 | 3 |
| 5. | CS4739 | Project - I | AEMC-2 | 0 | 0 | 8 | 4 |
| 6. | CS4738 | Internship | VAC-6 | 0 | 0 | 4 | 2 |
| | | **Total** | | 12 | 0 | 18 | 21 |

**Semester VIII**

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS4800 | Departmental Elective - V | DEC-5 | 3 | 0 | 0 | 3 |
| 2. | OEC | Open Elective course - II | OEC-2 | 3 | 0 | 0 | 3 |
| 3. | CS4835 | Seminar | AEMC-3 | 0 | 0 | 2 | 1 |
| 4. | CS4839 | Project - II | AEMC-4 | 0 | 0 | 12 | 6 |
| | | **Total** | | 6 | 0 | 14 | 13 |
| ***For those students carrying out project work in Industries/Organizations*** | | | | | | | |
| 1. | CS4840 | Industrial Project | | 0 | 0 | 8 | 4 |
| 2. | CS4841 | Project Seminar | | 0 | 0 | 10 | 5 |
| 3. | CS4842 | Comprehensive Viva | | 0 | 0 | 8 | 4 |
| | | **Total** | | 0 | 0 | 26 | 13 |

***List of Basic Science Courses***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CH 1101 | Engineering Chemistry | BSC-1 | 3 | 0 | 2 | 4 |
| 2. | MA 1101 | Engineering Mathematics-I | BSC-2 | 3 | 0 | 0 | 3 |
| 3. | PH 1101 | Engineering Physics-I | BSC-3 | 3 | 0 | 2 | 4 |
| 4. | MA 1201 | Engineering Mathematics-II | BSC-4 | 3 | 0 | 0 | 3 |
| 5. | MA2301 | Engineering Mathematics III | BSC-5 | 3 | 0 | 0 | 3 |
| 6. | MA2401 | Probability and Random Processes | BSC-6 | 3 | 0 | 0 | 3 |
| 7. | MA3501 | Optimization Techniques | BSC-7 | 3 | 0 | 0 | 3 |
| | | **Total** | | 21 | 0 | 4 | 23 |

***List of Engineering Science Courses***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | ME1101 | Engineering Mechanics | ESC-1 | 3 | 1 | 0 | 4 |
| 2. | ME 1102 | Engineering Drawing | ESC-2 | 1 | 2 | 0 | 3 |
| 3. | CS 1201 | Introduction to Computing | ESC-3 | 3 | 0 | 4 | 5 |
| 4. | EE 1201 | Basic Electrical Engineering | ESC-4 | 3 | 0 | 2 | 4 |
| 5. | EC 1201 | Basic Electronics Circuits | ESC-5 | 3 | 0 | 2 | 4 |
| 6. | CE 1201 | Environmental Engineering | ESC-6 | 3 | 0 | 0 | 3 |
| 7. | ME 1201 | Engineering Workshop | ESC-7 | 1 | 0 | 4 | 3 |
| | | **Total** | | 17 | 3 | 12 | 26 |

***List of Skill Enhancement Courses***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | HS 1101 | Communication Skills | SEC-1 | 3 | 0 | 0 | 3 |
| 2. | HS2301 | Managerial Economics & Financial Accounting | SEC-2 | 3 | 0 | 0 | 3 |
| | | **Total** | | 6 | | | 6 |

***List of Ability Enhancement Mandatory Course***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS3639 | Minor Project | AEMC-1 | 0 | 0 | 4 | 2 |
| 2. | CS4739 | Project - I | AEMC-2 | 0 | 0 | 8 | 4 |
| 3. | CS4835 | Seminar | AEMC-3 | 0 | 0 | 2 | 1 |
| 4. | CS4839 | Project - II | AEMC-4 | 0 | 0 | 12 | 6 |
| | | **Total** | | 0 | 0 | 26 | 13 |

***List of Value Addition Courses***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | IC 1191 | Induction Programme* | VAC-1 | 0 | 0 | 0 | 0 |
| 2. | IC 1192 | Extra Academic Activity-I* | VAC-2 | 0 | 0 | 0 | 0 |
| 3. | IC 1291 | Extra Academic Activity-II* | VAC-3 | 0 | 0 | 0 | 0 |
| 4. | SA2391 | NCC/NSO | VAC-4 | 0 | 0 | 2 | 0 |
| 5. | SA2491 | NCC/NSO | VAC-5 | 0 | 0 | 2 | 0 |
| 6. | CS4738 | Internship | VAC-6 | 0 | 0 | 4 | 2 |
| | | **Total** | | 0 | 0 | 8 | 2 |

***List of Department Cores Courses***

| Sl. No. | Course Code | Course Name | Course Category | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | CS2301 | Data Structures | DCC-1 | 3 | 0 | 3 | 4.5 |
| 2 | CS2302 | Discrete Structures | DCC-2 | 3 | 0 | 0 | 3 |
| 3 | CS2303 | Digital Logic Design | DCC-3 | 3 | 0 | 3 | 4.5 |
| 4 | CS2304 | Programming in Python | DCC-4 | 3 | 0 | 2 | 4 |
| 5 | CS2401 | Formal Languages and Automata Theory | DCC-5 | 3 | 1 | 0 | 4 |
| 6 | CS2402 | Design and Analysis of Algorithms | DCC-6 | 3 | 0 | 3 | 4.5 |
| 7 | CS2403 | Computer Organization and Architecture | DCC-7 | 3 | 0 | 2 | 4 |
| 8 | CS2404 | Object Oriented Programming | DCC-8 | 3 | 0 | 3 | 4.5 |
| 9 | CS3501 | Software Engineering | DCC-9 | 3 | 0 | 0 | 3 |
| 10 | CS3502 | Operating Systems | DCC-10 | 3 | 0 | 3 | 4.5 |
| 11 | CS3503 | Compiler Design | DCC-11 | 3 | 0 | 3 | 4.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12. | CS3504 | Data Communication | DCC-12 | 3 | 0 | 0 | 3 |
| 13. | CS3601 | Database Management Systems | DCC-13 | 3 | 0 | 3 | 4.5 |
| 14. | CS3602 | Computer Networks | DCC-14 | 3 | 0 | 3 | 4.5 |
| 15. | CS3603 | Artificial Intelligence | DCC-15 | 3 | 0 | 0 | 3 |
| 16. | CS4701 | Computer Graphics | DCC-16 | 3 | 0 | 3 | 4.5 |
| 17. | CS4702 | Machine Learning | DCC-17 | 3 | 0 | 3 | 4.5 |
| | | **Total** | | 51 | 2 | 34 | 69 |

***List of Department Electives***

| Sl. No. | Course Code | Course Name | L | T | P | Credits | Category |
|---|---|---|---|---|---|---|---|
| 1. | CS3571 | Digital Image Processing | 3 | 0 | 0 | 3 | Elective-I |
| 2. | CS3572 | Computational geometry | 3 | 0 | 0 | 3 | |
| 3 | CS3573 | Computational Systems Biology | 3 | 0 | 0 | 3 | |
| 4. | CS3574 | Multimedia systems | 3 | 0 | 0 | 3 | |
| 5. | CS3575 | Logic in computer science | 3 | 0 | 0 | 3 | |
| 6. | CS3500 | SWAYAM/NPTEL Courses | 3 | 0 | 0 | 3 | |
| 7. | CS3671 | Human computer interaction | 3 | 0 | 0 | 3 | Elective-II |
| 8. | CS3672 | Algorithmic Game Theory | 3 | 0 | 0 | 3 | |
| 9 | CS3673 | Graph Theory | 3 | 0 | 0 | 3 | |
| 10. | CS3674 | Pattern recognition | 3 | 0 | 0 | 3 | |
| 11 | CS3675 | Learning with Kernels | 3 | 0 | 0 | 3 | |
| 12 | CS3676 | Advanced Computer Architecture | 3 | 0 | 0 | 3 | |
| 13 | CS3677 | Formal methods for system verification | 3 | 0 | 0 | 3 | |
| 14 | CS3678 | Distributed systems | 3 | 0 | 0 | 3 | |
| 15 | CS3600 | SWAYAM/NPTEL Courses | 3 | 0 | 0 | 3 | |
| 16. | CS3679 | Computation number theory & cryptography | 3 | 0 | 0 | 3 | Elective-III |
| 17. | CS3681 | Wireless sensor networks | 3 | 0 | 0 | 3 | |
| 18 | CS3682 | Parallel Algorithms | 3 | 0 | 0 | 3 | |
| 19 | CS3683 | Functional & logic programming | 3 | 0 | 0 | 3 | |

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|---|---|---|---|---|---|---|---|
| 20 | CS3684 | Semantics for programming languages | 3 | 0 | 0 | 3 | |
| 21 | CS3685 | Steganography | 3 | 0 | 0 | 3 | |
| 22 | CS3686 | Data Mining | 3 | 0 | 0 | 3 | |
| 23 | CS3687 | Optimization methods | 3 | 0 | 0 | 3 | |
| 24 | CS3688 | Information transmission & security | 3 | 0 | 0 | 3 | |
| 25 | CS3610 | SWAYAM/NPTEL Courses | 3 | 0 | 0 | 3 | |
| 26 | CS4771 | Speech Processing | 3 | 0 | 0 | 3 | Elective-IV |
| 27 | CS4772 | Information Storage and Retrieval | 3 | 0 | 0 | 3 | |
| 28 | CS4773 | Natural Language Processing | 3 | 0 | 0 | 3 | |
| 29 | CS4774 | Principles of Robotics | 3 | 0 | 0 | 3 | |
| 30 | CS4775 | Internet of Things | 3 | 0 | 0 | 3 | |
| 31 | CS4776 | Digital Watermarking | 3 | 0 | 0 | 3 | |
| 32 | CS4777 | Big Data | 3 | 0 | 0 | 3 | |
| 33 | CS4778 | Intelligent Systems And Interfaces | 3 | 0 | 0 | 3 | |
| 34 | CS4779 | Web development technologies | 3 | 0 | 0 | 3 | |
| 35 | CS4781 | Advanced operating systems | 3 | 0 | 0 | 3 | |
| 36 | CS4782 | Computer and Network Security | 3 | 0 | 0 | 3 | |
| 37 | CS4700 | Ethical Hacking | 3 | 0 | 0 | 3 | |
| 38 | CS4710 | SWAYAM/NPTEL Courses | 3 | 0 | 0 | 3 | |
| 39 | CS4800 | SWAYAM/NPTEL Courses | 3 | 0 | 0 | 3 | Elective-V |

***List of Open Electives***

| Sl. No. | Course Code | Course Name | L | T | P | Credits | Category |
|---|---|---|---|---|---|---|---|
| 1. | CS4751 | SWAYAM / NPTEL Courses | 3 | 0 | 0 | 3 | Elective-I |
| 2. | CS4752 | The Joy of Computing using Python | 3 | 0 | 0 | 3 | |
| 3. | CS4753 | Machine Learning | 3 | 0 | 0 | 3 | |
| 4. | CS4851 | SWAYAM / NPTEL Courses | 3 | 0 | 0 | 3 | Elective-II |
| 6. | CS4852 | Artificial Intelligence | 3 | 0 | 0 | 3 | |

**12.0 Syllabi**

| CS2301 | DATA STRUCTURES | L-T-P-C 3-0-3-4.5 |
|---|---|---|
| Prerequisite: CS1201<br>Syllabus :<br>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 :<br>1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.<br>2. M A Weiss, Data Structures and Problem Solving Using Java, Addison-Wesley, 1997. | | |
| References :<br>1. A M Tannenbaum, Y Langsam and M J Augenstein, Data Structures Using C++, Prentice Hall India, 1996.<br>2. A H Aho, J E Hopcroft and J Ullman, Data Structures and Algorithms, Addison-Wesley, 1987.<br>3. Robert Sedgewick, Algorithms in C++ Parts 1-4, Pearson Education, Third Edition, 1998.<br>4. Robert Sedgewick, Algorithms in C++ Part 5, Pearson Education, Third Edition, 2002 | | |

| CS2302 | DISCRETE STRUCTURES | L-T-P-C 3-0-0-3 |
|---|---|---|
| Prerequisite: NIL<br>Syllabus:<br>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, | | |

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| colourability, planarity, digraphs; Algebraic Structures: semigroups, groups, subgroups, homomorphisms, rings, integral domains, fields, lattices and Boolean algebras. |
| Texts :<br>1. C L Liu, Elements of Discrete Mathematics, 2/e, Tata McGraw-Hill, 2000<br>2. R C Penner, Discrete Mathematics: Proof Techniques and Mathematical Structures, World Scientific, 1999. |
| References :<br>1. R L Graham, D E Knuth, and O Patashnik, Concrete Mathematics, 2/e, Addison-Wesley, 1994.<br>2. K H Rosen, Discrete Mathematics & its Applications, 6/e, Tata McGraw-Hill, 2007.<br>3. J L Hein, Discrete Structures, Logic, and Computability, 3/e, Jones and Bartlett, 2010.<br>4. N Deo, Graph Theory, Prentice Hall of India, 1974.<br>5. S Lipschutz and M L Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2/e, Tata McGraw-Hill, 1999.<br>6. J P Tremblay and R P Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997. |

| | | |
|---|---|---|
| CS2303 | DIGITAL LOGIC DESIGN | L-T-P-C 3-0-3-4.5 |
| Prerequisite: NIL<br>Syllabus:<br>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. | | |

| CS2304 | PROGRAMMING IN PYTHON | L-T-P-C 3-0-2-4 |
|---|---|---|
| Prerequisite: CS1201<br><br>Syllabus: Introduction to algorithms - Variables, expressions, and statements, Conditional execution - Chained conditionals, Nested conditionals, Functions - Built-in functions, Parameters and arguments, Iterations and Ranges - Updating variables, The while statement, For Loops, Loop patterns, Collections in Python - Dictionaries, Lists, Tuples, Regular Expressions, File Operations, Module system in python, Object-oriented programming – Inheritance, Method overriding Data hiding, Basic Pandas and Numpy processing of data | | |
| Texts :<br><br>1. Luciano Ramalho , Fluent Python, O'Reilly Media, 2nd Edition, 2022<br><br>2. Charles R. Severance, Python for Everybody, Shroff Publishers, 2017, Link: http://do1.dr-chuck.com/pythonlearn/EN_us/pythonlearn.pdf | | |
| References :<br><br>1. Mark Lutz, Learning Python, O'Reilly Media, 2013<br><br>2. Reema Thareja, PYTHON PROGRAMMING 2E, OXFORD, 2023<br><br>3. Allen Downey, Jeffrey Elkner, Learning with Python, 2015<br><br>4. R. Nageswara Rao, Core Python Programming. 2021 | | |

| CS2401 | FORMAL LANGUAGES AND AUTOMATA THEORY | L-T-P-C 3-1-0-4 |
|---|---|---|
| Prerequisite: NIL<br>Syllabus:<br>Alphabets, languages, grammars; Finite automata: regular languages, regular expressions; Context -free languages: pushdown automata, DCFLs; Context sensitive languages: linear bounded automata; Turing | | |

| CS2401 | FORMAL LANGUAGES AND AUTOMATA THEORY | L-T-P-C 3-1-0-4 |
|---|---|---|
| machines: recursively enumerable languages; Operations on formal languages and their properties; Chomsky hierarchy; Decision questions on languages. | | |
| Texts :<br>1. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2/e, Pearson Education, 2000. | | |
| References :<br>1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.<br>2. H. R. Lewis, C. H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia, 2001.<br>3. D. C. Kozen, Automata and Computability, Springer-Verlag, 1997. | | |

| CS2402 | DESIGN AND ANALYSIS OF ALGORITHMS | L-T-P-C 3-0-3-4.5 |
|---|---|---|
| Prerequisite: CS2301 and CS2302<br>Syllabus:<br>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 :<br>1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.<br>2. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison Wesley, 2005. | | |
| References :<br>1. A Aho, J E Hopcroft and J D Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley, 1974.<br>2. S Sahni, Data Structures, Algorithms and Applications in C++, McGraw-Hill, 2001.<br>3. M T Goodrich and R Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, John Wiley & Sons, 2001. | | |

| CS2403 | COMPUTER ORGANIZATION AND ARCHITECTURE | L-T-P-C 3-0-3-4.5 |
|---|---|---|

Prerequisite: CS2303
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 :
1. William Stallings, Computer Organization and Architecture: Designing for Performance, 8/e, Pearson Education India. 2010.
2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design, 4/e, Morgan Kaufmann, 2008.

References :
1. A. S. Tanenbaum, Structured Computer Organization, 5/e, Prentice Hall of India, 2009.
2. V. C. Hamacher, Z. G. Vranesic and S. G. Zaky, Computer Organization, 5/e, McGraw Hill, 2002.
3. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, 4/e, Morgan Kaufmann, 2006.
4. D. V. Hall, Microprocessors and Interfacing, 2/e, McGraw Hall, 2006.

| CS2404 | OBJECT ORIENTED PROGRAMMING | L-T-P-C 3-0-3-4.5 |
|---|---|---|

Prerequisite: NIL
Syllabus:
Introduction to Object-Oriented Programming: History and evolution, Key concepts: classes, objects, inheritance, polymorphism; Classes and Object: Defining classes, Creating objects, Constructors and destructors; Inheritance: Types of inheritance, Implementing inheritance in C++ and Java, Overriding methods; Polymorphism: Static vs dynamic polymorphism, Operator overloading, Method overloading and overriding; Encapsulation and Abstraction: Data hiding, Access specifiers, Abstract classes and interfaces; Exception Handling: Types of exceptions, Try-catch blocks, Custom exceptions; File Handling: Reading and writing files, Serialization and deserialization; Templates and Generics: Template functions and classes in C++, Generics in Java and Python; Standard Template Library (STL): Containers, Iterators, Algorithms; Design Patterns: Introduction to design patterns, Common design patterns: Singleton, Factory, Observer; Advanced Topics: Multithreading and concurrency, Network programming, GUI development;

| CS2404 | OBJECT ORIENTED PROGRAMMING | L-T-P-C 3-0-3-4.5 |
|---|---|---|
| Project and Case Studies: Building a small project using object-oriented concepts, Case studies of real-world applications. | | |
| Textbooks:<br>1. Object-Oriented Programming in C++ By Robert Lafore<br>2. Object Oriented Programming with C++ by Balaguruswamy, TMH<br>3. Dietel H.M, Dietel P.J, "Java: How to Program", Prentice-Hall, 7th Edition, 2006.<br>4. Flanagan D, "Java in a Nutshell", O'Reilly Media, Inc., 5th Edition. 2005. | | |
| References :<br>1. Object Oriented Programming By- Budd, Addison Wesley.<br>2. Mastering C++ By K.R Venugopal , Rajkumar, TMH.<br>3. An Introduction to Object Oriented Programming with C++ by Timthy Budd, Addition-Wesley<br>4. C++ and Object-Oriented Programming By - Kip R. Irvine, Prentice Hall.<br>5. P. Radha Krishna, “Object Oriented Programming through Java”, Universities Press, 2nd Edition, 2007<br>6. Bruce Eckel, “Thinking in Java”, Pearson Education, 4th Edition,2006 | | |

| CS3501 | SOFTWARE ENGINEERING | L-T-P-C 3-0-0-3 |
|---|---|---|
| Prerequisite: NIL<br>Syllabus:<br>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 :<br>1. Pressman, R.S., Software Engineering: A Practioner's Approach, McGraw Hill, seventh edition, 2010. | | |
| References:<br>1. Sommerville, Ian, Software Engineering, Addison-Wesley, fifth edition, 2000.<br>2. Jalote, P., An Integrated Approach to Software Engineering, Narosa Publishing House, second edition, 2003.<br>3. Bennett S., McRobb S. & Farmer R., Object Oriented Systems Analysis and Design using UML, Tata McGraw-Hill, second edition, 2004. | | |

| CS3502 | OPERATING SYSTEMS | L-T-P-C 3-0-3-4.5 |
|---|---|---|
| Prerequisite: CS2402 and CS2403<br>Syllabus:<br>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 :<br>1. Silberschatz, A. and Galvin, P. B. Operating System Concepts. 8/e. Wiley, 2008. | | |
| References :<br>1. Stalling, W. Operating Systems: Internals and Design Principles. 6/e. Pearson, 2008.<br>2. Tanenbaum, A. S. Modern Operating System. 3/e. Pearson, 2007.<br>3. Dhamdhere, D. M. Operating SystemsA Concept Based Approach, McGrawHill, 2008. | | |

| CS3503 | COMPILER DESIGN | L-T-P-C 3-0-3-4.5 |
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| Prerequisite: CS2401<br>Syllabus:<br>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<br>allocation, code-generation algorithms; Introduction to code optimization techniques. | | |
| Texts :<br>1. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques, and Tools, 2nd Edition, Prentice Hall, 2009. | | |
| References :<br>1. V. Raghavan, Principles of Compiler Design, McGrawHill, 2010.<br>2. C.N. Fischer, R.J. Le Blanc, Crafting a Compiler with C, Pearson Education, 2009.<br>3. K. D. Cooper, L. Torczon, Engineering a Compiler, Morgan Kaufmann Publishers, 2004. | | |

| CS3504 | DATA COMMUNICATION | L-T-P-C 3-0-0-3 |
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Prerequisite: NIL

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

| CS3571 | DIGITAL IMAGE PROCESSING | L-T-P-C 3-0-0-3 |
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Syllabus:

Introduction - Elements of digital image processing systems, Elements of visual perception, brightness, contrast, hue, saturation, mach band 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.

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| Morphology - Preliminaries, dilation, erosion, open and closing, hit or miss transformation, basic morphologic algorithms. |
| Texts :<br>1. Digital Image Processing, Rafael C.Gonzalez, Richard E.Woods, Second Edition, Pearson Education/PHI, 2000.<br>2. . W.K.Pratt, Digital Image Processing ,3/e Edn., John Wiley & sons, Inc. 2006.<br>3. K. R. Castleman, Digital Image Processing, Pearson, 2006.<br>4. Anil K. Jain, Fundamental of image processing, Pearson, 2002. |
| References :<br>1. Image Processing, Analysis, and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Second Edition, Thomson Learning, 2008.<br>2. Introduction to Digital Image Processing with Matlab, Alasdair McAndrew, Thomson Course Technology,2001.<br>3. Computer Vision and Image Processing, Adrian Low, Second Edition, B.S. Publications, 2005.<br>4. Digital Image Processing using Matlab, Rafael C.Gonzalez, Richard E.Woods, Steven L. Eddins, Pearson Education, 2007. |

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| CS3572 | COMPUTATIONAL GEOMETRY | L-T-P-C 3-0-0-3 |
| Syllabus:<br>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 :<br>1. F. P. Preparata and M. I. Shamos, Computational Geometry: An Introduction, Springer-Verlag, 1985. | | |
| References :<br>1. J. O'Rourke, Computational Geometry in C, 2nd Ed, Cambridge University Press, 1998.<br>2. M. Laszlo, Computational Geometry and Computer Graphics in C++, Prentice-Hall, 1996.<br>3. M. De Berg, M. van Kreveld, M. Overmars, O. Schwarzkopf, Computational Geometry: Algorithms and Applications, Springer -Verlag, 1997. | | |

| CS3573 | COMPUTATIONAL SYSTEMS BIOLOGY | L-T-P-C 3-0-0-6 |
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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 s uch 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.

| CS3574 | MULTIMEDIA SYSTEMS | L-T-P-C 3-0-0-3 |
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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.

| CS3575 | LOGIC IN COMPUTER SCIENCE | L-T-P-C 3-0-0-3 |
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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.

| CS3601 | DATABASE MANAGEMENT SYSTEMS | L-T-P-C 3-0-3-4.5 |
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Prerequisite: NIL
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 :
1. A. Silberschatz, H. F. Korth and S. Sudarshan, Database System Concepts, 5/e, McGraw Hill, 2006
2. R. Ramakrishnan and J. Gehrke, Database Management Systems, 3/e, McGraw Hill, 2003

References :
1. Elmasri R, Navathe S B, Fundamentals of Database Systems, Benjamin Cummings Publishing Company, 1994.
2. ONeil P., Database : Principles, Programming, Performance, Morgan Kaufmann, 1994.
3. Theorey T J, Database Modeling & Design, 2/e, Morgan Kaufmann Publishers, 1994.
4. Melton J, Simon A R, SQL: A Complete Guide, Morgan Kaufmann Publishers, 1993.
5. H. GarciaMolina, J. D. Ullman and J. Widom, Database Systems The Complete Book,1/e, Pearson Education, 2CS4727

| CS3602 | COMPUTER NETWORKS | L-T-P-C 3-0-3-4.5 |
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Prerequisite: CS2402
Syllabus:
Evolution of computer networks; Data link layer: Framing, HDLC, PPP, flow control, sliding window protocols, performance , medium access control, Token Ring, Virtual circuit switching: Frame relay, Network Layer: Internet addressing, class of address, IP, ARP, ICMP, CIDR, routing algorithms (RIP, OSPF, BGP); Transport Layer: UDP, TCP, flow control, congestion control; Application Layer: DNS, Web, email, authentication, encryption.

Texts :

1. L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, 4th Ed, Elsevier India, 2007.
2. A. S. Tanenbaum, Computer Networks, 4th Ed, Pearson India, 2003.

References :

1. J. F. Kurose and K. W. Ross, Computer Networking: A Top down Approach, 3rd Ed, Pearson India, 2005.
2. D. E. Comer, Internetworking with TCP/IP Vol. 1, 5th Ed, Prentice Hall of India, 2006.
3. S. Keshav, An Engineering Approach to Computer Networking, 1st Ed, Pearson India, 1999.
4. B. Forouzan, Data Communications and Networking, 4th Ed, Tata McGraw Hill, 2006.

| CS3603 | ARTIFICIAL INTELLIGENCE | L-T-P-C 3-0-0-3 |
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Prerequisite: CS2301

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.

| CS3671 | HUMAN COMPUTER INTERACTION | L-T-P-C 3-0-0-3 |
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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,

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| 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,<br>multimedia. |
| Texts :<br>1. A. Dix, J. Finlay, G. D. Abowd and R. Beale, Human Computer Interaction, 3rd edition, Pearson Education, 2005. |
| References :<br>1. J. Preece, Y. Rogers, H. Sharp, D. Baniyon, S. Holland and T. Carey, Human Computer Interaction, Addison-Wesley, 1994.<br>2. C. Stephanidis (ed.), User Interface for All: Concepts, Methods and Tools. Lawrence Erlbaum Associates, 2001.<br>3. J. M. Caroll (ed.), HCI Models, Theories and Frameworks: Towards a Multidisciplinary Science (Interactive Technologies), Morgan Kauffman, 2003.<br>4. W. O Galitz, The Essential Guide to User Interface Design, John Wiley & Sons, Inc, 2002 (Indian Edition).<br>5. B. Shneiderman, Designing the User Interface, Addison Wesley, 2000 (Indian Reprint). |

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| CS3672 | ALGORITHMIC GAME THEORY | L-T-P-C 3-0-0-3 |
| Syllabus:<br>Games and equilibria, two player Zero-Sum Games, proof of Nash Equilibria, complexity of finding Nash equilibria,information, strategies, dynamic and repeated games, bargaining, auctions, market equilibria, algorithmic mechanism design, inefficiency of equilibria, routing games, load balancing games. | | |
| Texts :<br>1. N. Nisan, T. Roughgarden, V. Vazirani and E. Tardos, Algorithmic Game Theory, Cambridge University Press, 2007.<br>2. E. Rasmusen, Games and Information: An Introduction to Game Theory, 4th Edn., Wiley-Blackwell, 2006.<br>3. M. J. Osborne and A. Rubinstein, A Course in Game Theory, The MIT press, 1994. | | |
| References :<br>1. V. Krishna, Auction theory, Elsevier, 2002.<br>2. K. R. Apt and E. Graedel, Lectures in Game Theory for Computer Scientists, Cambridge University Press, 2011. | | |

3. J. von Neumann and O. Morgenstern, Theory of Games and Economic Behavior, Princeton Univ. Press, 1944.

| CS3673 | GRAPH THEORY | L-T-P-C 3-0-0-3 |
|---|---|---|

Syllabus:
Graphs and subgraphs, isomorphism, walks, path and circuit, traveling salesman problem, trees, spanning trees, cut sets, connectivity and separability, network flows; Combinatorial and geometric graphs, planar graphs, geometric dual, thickness and crossings, vectors and vector spaces, circuit and cut set subspaces, orthogonal vectors and spaces, matrix representation of graphs; Chromatic number, chromatic partitioning, matching and coverings, vertex cover
and set cover, Bipartite graphs, digraphs, enumeration of graphs; Basic graph algorithms: connectedness, components, spanning tree, shortest path, performance of graph-theoretic algorithms, planarity testing, isomorphism testing; Graph theory applications: contact networks, switching networks, computer networks and routing, game theory, operation research, flow problems.

Texts:
1.Introduction to Graph Theory, Douglas West, 2nd Edition, Pearson, 2015.
2. Graph theory with applications to engineering and computer science, N. Deo, PHI, India, 1979.

References :
1. J. M. Aldous. Graphs and Applications. Springer, LPE, 2007.
2.J. A. Bondy and U. S. R. Murty. Graph Theory with Applications.North-Holland, 1976.

| CS3674 | PATTERN RECOGNITION | L-T-P-C 3-0-0-3 |
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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.

| CS3675 | LEARNING WITH KERNELS | L-T-P-C 3-0-0-3 |
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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.

| CS3676 | ADVANCED COMPUTER ARCHITECTURE | L-T-P-C 3-0-0-3 |
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Syllabus:
Pipeline processor principles and design, Instruction set architecture; Memory addressing; Instruction composition; Instruction-level parallelism; Hazards: dynamic scheduling, branch prediction; Memory

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| hierarchy; Processor case studies; Multiprocessor introduction: Shared-memory architectures and their synchronisation and consistency issues, Advanced multi-core topics; Transactional Memory; Interconnection networks. |
| Texts :<br>1. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, fourth edition, 2006.<br>2. David Culler, J.P. Singh and Anoop Gupta, Parallel Computer Architecture: A Hardware/Software Approach, Morgan Kaufmann, first edition, 1998. |
| References :<br>1. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill, first edition, 1992. |

| CS3677 | FORMAL METHODS FOR SYSTEM VERIFICATION | L-T-P-C 3-0-0-3 |
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| Syllabus:<br>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<br>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 :<br>1. M. Huth and M. Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, 2nd Ed, Cambridge University Press, 2004 | | |
| References :<br>1. T. F. Melham, Higher Order Logic and Hardware Verification, Cambridge University Press, 1993.<br>2. E. M. Clarke, O. Grumberg and D. Peled, Model Checking, MIT Press, 1999.<br>3. K. L. McMillan, Symbolic Model Checking, Kluwer Academic Publisher, 1993.<br>4. Z. Manna and A. Pnueli, The Temporal Logic of Reactive and Concurrent System Specification, Springer-Verlag, 1992. | | |

| CS3678 | DISTRIBUTED SYSTEMS | L-T-P-C 3-0-0-3 |
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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.

| CS3679 | COMPUTATIONAL NUMBER THEORY AND CRYPTOGRAPHY | L-T-P-C 3-0-0-3 |
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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.

| CS3681 | WIRELESS SENSOR NETWORKS | L-T-P-C 3-0-0-3 |
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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.

References :
1. Wireless Sensor Networks : Architecture and Protocols By Jr., Edgar H. Callaway.
2. Wireless Sensor Networks, An Edited Book Editors : C.S Raghavendra, Krishna M. Sivalingam and Taieb Znati.

| CS3682 | PARALLEL ALGORITHMS | L-T-P-C 3-0-0-3 |
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Syllabus:
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

| CS3683 | FUNCTIONAL AND LOGIC PROGRAMMING | L-T-P-C 3-0-0-3 |
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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.

| CS3684 | SEMANTICS OF PROGRAMMING LANGUAGES | L-T-P-C 3-0-0-3 |
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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 subs

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.

| CS3685 | STEGANOGRAPHY | L-T-P-C 3-0-0-3 |
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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

References :
1. Intelligent Watermarking Techniques, J-S Pan, H-C Huang, L.C. Jain, World Scientific Pub. Co., 2004
2. Aliroo Home page, "www.aliroo.com
3. "ImageLock Home page", www.imagelock.com
4. "Digimarc Home page", www.digimarc.com

| CS3686 | DATA MINING | L-T-P-C 3-0-0-3 |
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| Syllabus:<br>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 :<br>1. S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998. | | |
| References :<br>1. S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004. | | |

| CS3687 | OPTIMIZATION METHODS | L-T-P-C 3-0-0-3 |
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| Syllabus:<br>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:<br>1. V. Chavtal, Linear Programming, W. H. Freeman and Company, New York, 1983.<br>2. C. H. Papadimitriou and K. steiglitz, Combinatorial optimization: Algorithms and Complexity, Dover Publications, Inc., New York, 1998. | | |
| References:<br>1. M. Grotschel, L. Lovasz and A. Schrijver, Geometric Algorithms and Combinatorial Optimization, John Wiley & Sons, Inc., New York, 1998.<br>2. W. Cook, W. H. Cunningham, W. R. Pulleyblank and A. Schrijver, Combinatorial Optimization, John Wiley & Sons, Inc., New York, 1998.<br>3. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995.<br>4. Related publications in Journals/Conferences | | |

| CS3688 | INFORMATION TRANSMISSION AND SECURITY | L-T-P-C 3-0-0-3 |
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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)

| CS4701 | COMPUTER GRAPHICS | L-T-P-C 3-0-3-4.5 |
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Prerequisite: CS2402
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

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| 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 :<br>1. D. Hearn and M. P. Baker, Computer Graphics with OpenGL, 3/e, Pearson, 2009. |
| References :<br>1. E. Angel. Interactive Computer Graphics: A Top-Down Approach using OpenGL, 5/e, Pearson, 2009.<br>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.<br>3. P. Shirley and S. Marschner. Computer Graphics. India Edition, Cengage Learning, 2009.<br>F. S. Hill. Computer Graphics using OpenGL, 3/e, Pearson, 2009. |

| CS4702 | MACHINE LEARNING | L-T-P-C 3-0-3-4.5 |
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| Prerequisite:3603<br>Syllabus:<br>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 :<br>1. Ethem Alpaydin, Introduction to Machine Learning, Second Edition, PHI, 2010<br>2. Machine Learning, Tom Mitchell, McGraw Hill, 1997. | | |
| References :<br>1. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995. | | |

| CS4771 | SPEECH PROCESSING | L-T-P-C 3-0-0-3 |
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Syllabus: Introduction to Speech Processing, human and machine speech production:Models for speech production. Various types of speech sounds and their characteristics, Speech hearing: Mechanism for human hearing: Learning to recognize human sounds, acquired knowledge vs vocabulary - based methods. Analysis of speech: Frequency and time domain based methods: FFT, computation of pitch, spectrograms, LPC, cepstrum, ZCR, etc. Representation of acoustic events. Components of a Speech recognition system: Input, feature analysis, modelling and decision rule, vocabulary. Data compression: Vector Quantization, codebook design, Lloyd's quantizer design, K-means algorithm, LBG algorithm for speech. Speech modelling: Stochastic processes: Markov processes, Hidden Markov modelling. Components of an HMM, training and building of HMMs: Viterbi algorithm, Baum-Welch algorithm, etc. Implementation of a speech recognition system: Time/space consideration, designing the interface, self-learning mechanism.

Texts:

1. L. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall, 1993.
2. L. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.
3. K. Sayood, Introduction to Data Compression, 2nd Ed, Morgan Kaufmann, 2000.

References:

1. D. O'Shaughnessy, Speech Communications: Human and Machine, 2nd Ed, IEEE Press, 2000.
2. A. Gersho and R. M. Gray, Vector Quantization and Signal Compression, Kluwer Academic, 1991.
3. Selected research papers.

| CS4782 | COMPUTER AND NETWORK SECURITY | L-T-P-C 3-0-0-3 |
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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. Practical Security Setup & Review: Installing Unix &

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

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| CS4772 | INFORMATION STORAGE AND RETRIEVAL | L-T-P-C 3-1-0-4 |
| Syllabus:<br>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, 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. | | |

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.

| CS4773 | NATURAL LANGUAGE PROCESSING | L-T-P-C 3-0-0-3 |
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Syllabus:
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.

References:
1. McDonald & Bolc. (Ed.): Natural Language Generation Systems, Springer Verlag, 1987.
2. W. J. Hutchins: Machine Translation - Past, Present & Future, Ellis Horwood, 1986.
3. Bharati, Chaitanya and Sangal: Natural Language Processing- a Paninian perspective, PHI, 1985.

| CS4774 | PRINCIPLES OF ROBOTICS | L-T-P-C 3-0-0-3 |
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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.

| CS4775 | INTERNET OF THINGS | L-T-P-C 3-0-0-3 |
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Syllabus:
Introduction to IoT: What is IoT, Impact of IoT, IoT Challenges. IoT network architecture & design: oneM2M, IoTWF, Core functional stack, Data management stack. 'Things' in IoT: Sensors, Actuators, Smart objects, Basics of Sensor Networks. Communicating smart objects: Communication criteria, IoT access technologies- IEEE 802.15.4, IEEE 802.15.4e, IEEE 802.11ah, IEEE 1901.2a, NB-IoT. IoT Network Layer: IP as IoT network layer, 6LoWPAN, 6Lo, 6TiSCH, RPL. IoT Application Layer: IoT application transport methods, CoAP, MQTT. Data and Analytics for IoT: IoT Middleware, Data analytics for IoT, Big Data analytics tools and technology. IoT application case study: Smart City, Smart Grid, Smart Transportation, Smart Manufacturing, Smart Healthcare.

Text:
1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry; IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 1st Edition, Pearson India Pvt. Ltd., 2018.
2. A. Bahga, V. Madisetti; Internet of Things: A Hands-on Approach, 1st Edition, Universities Press (India) Pvt. Ltd., 2015.

References:
1. Y. Kanetkar, S. Korde; 21 Internet of Things (IOT) Experiments: Learn IoT, the programmer's way, 1st Edition, BPB Publications, 2018.

| CS4776 | DIGITAL WATERMARKING | L-T-P-C 3-0-0-3 |
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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

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| 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. |
| Texts:<br>1. Information Hiding (Steganography and Watermarking - Attacks and Countermeasures), Johnson, Neil F./ Duric, Zoran/ Jajodia, Sushil , luwer Academic Pub, 2001<br>2. Information Hiding Techniques for Steganography and Digital Watermarking ,Katzenbeisser, Stefan (Edt)/ Petitcolas, Fabien, A.P. (Edt) , Artech House, 2000 |
| References:<br>1. Intelligent Watermarking Techniques, J-S Pan, H-C Huang, L.C. Jain, World Scientific Pub. Co., 2004<br>2. Aliroo Home page, "www.aliroo.com<br>3. "ImageLock Home page", www.imagelock.com<br>4. "Digimarc Home page", www.digimarc.com |

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| CS4777 | BIG DATA | L-T-P-C 3-0-0-3 |
| Syllabus:<br>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<br>Unstructured Data (MapReduce and Hadoop), The Hadoop Ecosystem, In-database Analytics – SQL Essentials, Advanced SQL and MADlib for in-database. | | |
| Texts:<br>1. "Big Data" by Viktor Mayer-Schönberger, Kenneth Cukier, ISBN:978- 0544002692, Eamon Dolan/Houghton Mifflin Harcourt 2013<br>2. "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence" by Pramod J. Sadalage, Martin Fowler, ISBN:978- 0321826626, Addison-Wesley,<br>2012 | | |
| References:<br>1. “Hadoop Operation”, by Eric Sammer, ISBN: 978-1449327057, O’Reilly 2012<br>2. “MapReduce Design Patterns: Building Effective Algorithms and Analytics for Hadoop and Other Systems”, by Donald Miner, Adam Shook, ISBN: 978-1449327170,<br>O’Reilly 2012<br>3. “Big Data Now”, by O’Reilly Media Inc., ASIN: B0097E4EBQ, O’Reilly 2012 | | |

| CS4778 | INTELLIGENT SYSTEMS AND INTERFACES | L-T-P-C 3-0-0-3 |
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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 :
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.

References :
1. T. M. Mitchell, Machine learning, McGraw-Hill 1997.
2. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000

| CS4779 | WEB DEVELOPMENT TECHNOLOGIES | L-T-P-C 3-0-0-3 |
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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:
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.

References:
1. B. Breedlove, Web Programming Unleashed, Sams Net Publishing, 1996.
2. C. Musciano and B. Kennedy, HTML: The Definitive Guide, 2nd Ed, O'Reilly, May 1997.
3. L. Wall, T. Christiansen and R. L. Schwartz, Programming Perl, O'Reilly, 1996; also published by Shroff Publishers and Distributors Pvt. Ltd.
4. S. Gundavaram, CGI Programming on the World Wide Web, O'Reilly, March 1996.

5. D. Flanagan, Java in a Nutshell, O'Reilly, 1997 (also published by Shroff Publishers and Distributors Pvt. Ltd., Mumbai)
6. Other references and whitepapers on Java, HTML etc.

| CS4781 | ADVANCED OPERATING SYSTEMS | L-T-P-C 3-0-0-3 |
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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:
1. M. K. McKusick et al., The Design and Implementation of the 4.4 BSD Operating System, Addison Wesley, 1996.

References:
1. 1. B. Goodheart and J. Cox, The Magic Garden Explained: The Internals of Unix System V Release 4, Prentice Hall 1994.
2. U. Vahalia, Unix Internals: The New Frontiers, Prentice Hall, 1996.
3. P. K. Sinha, Distributed Operating Systems, Wiley-IEEE Press, 1996.
4. H. Custer, Inside Windows NT, 2nd Ed, Microsoft Press, 1998.

| CS4753 | MACHINE LEARNING | L-T-P-C 3-0-0-3 |
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Prerequisite:3603
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. Machine Learning, Tom Mitchell, McGraw Hill, 1997.

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| References :<br>1. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995. |

| CS4852 | ARTIFICIAL INTELLIGENCE | L-T-P-C 3-0-0-3 |
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| Prerequisite: CS2301<br>Syllabus:<br>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.<br>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:<br>1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003. | | |
| References:<br>1. E. Rich and K. Knight, Artificial Intelligence, McGraw Hill, 1991.<br>2. P. H. Winston and B. K. P. Horn, Lisp, 3rd Ed, Addison-Wesley, 1989.<br>3. P. Norvig, Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp, Morgan Kauffman, 1991. | | |