Department of Computer Science & Engineering
Indian Institute of Technology Patna

Course Structure for **M.Tech in Computer Science and Engineering**

Objective:

The proposed M.Tech (CSE) program is intended to fill an existing gap within the industries and academic institution of trained professionals. The prospective students will be well trained in both the theoretical and application aspects of computer science and engineering.

Eligibility:

- B.Tech. in C.S.E or equivalent degree with valid GATE score in C.S..
- B.Tech from IITs with CPI > 8.0 (as per the institute rule)
- In addition, candidates sponsored by an industry/R&D organization are also considered. Sponsored candidates must have at least 60% marks in the qualifying examination and at least two years of work experience. GATE score is not mandatory for sponsored candidates.
- Intake capacity: 15 + 5 (sponsored)

Two Sets of Electives out of which the electives to be floated in 1st sem from the List -1, while in 2nd sem from the list-2

Theory Courses: 8 (4 core and 6 electives); **Lab Courses**: 2

Total Credits: 175 2 Years (4 semester programme)

COURSE STRUCTURE

1st Semester

Course Id	Course Name	Structure
CS541	Foundations of Computer Systems	3-0-0=6
MA501	Probability, Statistics and Stochastic Process	3-0-0=6
CS558	Computer Systems Lab-1	0-0-6=6
CS591	Seminar-I	0-0-4=4
Elective-I		3-0-0=6
Elective-II		3-0-0=6
Elective-III		3-0-0=6

Total Credit: 40

2nd Semester

Course Id	Course Name	Structure
CS511	Foundations of Theoretical Computer Science	3-0-0=6
CS512	Data Structure and algorithms	3-0-0=6
CS513	Computer Systems Lab-2	0-0-6=6
CS592	Minor Project / Seminar	0-0-4=4
Elective-IV		3-0-0=6
Elective-V		3-0-0=6
Elective-VI		3-0-0=6

Total Credit: 40

3rd Semester

Course Id	Course Name	Structure
CS 691	Comprehensive Viva	0-0-0=10
CS698	Project Thesis -I	0-0-0=40

Total Credit: 50

4th Semester

Course Id	Course Name	Structure
CS699	Project Thesis - II	0-0-0=45

Total Credit: 45

Total Credits= 40+40+50+45=175

List of Electives

Group-1 (Floated in 1st Sem depending on the instructor's choice. More specialized electives will be added further.)

1. CS561 Artificial Intelligence
2. CS542: Software Testing
3. CS543: Distributed Systems
4. MA511: Large Scale Scientific Computing (Maths)
5. CS 528CAD for VLSI

Group-2 (Likely to be floated in 2nd Sem depending on the instructor's choice More specialized electives will be added further)

6. CS 548 Wireless Networks
7. CS549 Computer and Network Security
8. CS 508 Formal methods for analysis and verification
9. CS743: Advanced topics on Database
10. CS502: Pattern Recognition

Detailed Syllabus

CS541 Foundations of Computer Systems **(3 0 0 6)**

Review of concepts of computer architecture: Study of an existing CPU: architecture, instruction set and the addressing modes, assembly language programming. Control unit Design: instruction interpretation, hardwired and micro-programmed methods of design. Pipelining and parallel processing, RISC and CISC paradigms, I/O Transfer techniques: programmed, interrupt-driven and DMA; Memory organization: hierarchical memory systems, cache memories, cache coherence, virtual memory.

Review of concepts of operating systems: Processes, threads, Unix fork-exec model, Unix signals, Interprocess communication, scheduling, memory management.

Review of concepts of computer networks: link layer protocols, local area networks (Ethernet and variants), interconnecting networks with IP, routing, transport layer protocols. Advanced concepts of distributed networked systems: Virtualization, distributed file systems, mass storage systems, recovery and fault tolerance, content networking including multimedia delivery

Texts :

1. A. Silberschatz, P. B. Galvin and G. Gagne, Operating System Concepts, 7th Ed, John Wiley and Sons, 2004.

2. J. Kurose and K. W. Ross, Computer Networking: A Top down approach, 3rd Ed, Pearson India, 2004.

3. M. Singhal and N. Shivratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.

4. A. S. Tanenbaum and Van Steen, Distributed Systems: Principles and Paradigms, Prentice Hall India, 2007.

CS511 Foundations of Theoretical Computer Science **(3 0 0 6)**

Discrete Structures -- Sets, Relations and Functions; Proof Techniques, Algebraic Structures, Morphisms, Posets, Lattices and Boolean Algebras. **Logic** -- Propositional calculus and Predicate Calculus, Satisfiabiliy and validity, Notions of soundness and completeness. **Automata and Languages** -- Finite automata and regular expressions, pushdown automata and context-free grammars, pumping lemmas and closure properties of regular and context-free languages, non-context-free languages. **Computability theory** -- Church-Turing thesis, Hilbert's problem,

decidability, halting problem, reducibility; Complexity theory: time and space complexity, Classes P, NP, NP-complete, PSPACE, and PSPACE-complete.

Texts:

1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
2. H. R. Lewis, C. H. Papadimitriou, Elements of the Theory of Computation, PHI, 1981.

References:

1. J. E. Hop croft, J. D. Ullman, Introduction to Automata Theory, Languages and Computation,Narosa,1979.
2. S. Arora, B. Barak, Computational Complexity: A Modern Approach, Cambridge UniversityPress,2009.
3. C. H. Papadimitriou, Computational Complexity, Addison-Wesley Publishing Company, 1994.
4. D.C.Kozen, Theory of Computation, Springer, 2006.
5. D. S. Garey, G. Johnson, Computers and Intractability: A Guide to the Theory of NP-Completeness, Freeman, New York, 1979.

CS 512 Data Structure and Algorithms (3 0 0 6)

Problem Solving using Computers - Abstraction - Abstract data types; Data Representation; Elementary data types; Basic concepts of data Structures; Mathematical preliminaries - big-Oh notation; efficiency of algorithms; notion of time and space complexity; performance measures for data structures.
ADT array - Computations on arrays -sorting and searching algorithms. ADT Stack, Queue, list - array, linked list, cursor based implementations of linear structures.
ADT Tree - tree representation, traversal of trees;
ADT Binary tree - binary trees, threaded binary trees, application of binary trees - Huffman coding; application of threaded binary trees - differentiation;
Search Tree - Binary search tree; balanced binary search trees - AVL tree; Applications of Search Trees - TRIE; 2-3 tree, 2-3-4 tree; concept of B-Tree.
ADT Dictionary - array based and tree based implementations; hashing - definition and application - LZW encoding. ADT Priority Queue - Heaps; heap-based implementations; applications of heaps - sorting;
Graphs - shortest path, minimum spanning tree, DFS, BFS - an application of DFS and BFS.
Algorithm Design Paradigms - greedy, divide and conquer, dynamic Programming, backtracking.

References:

1. Mark Allen Weiss, "Data Structures and Algorithms in C++", Addison Wesley, 2003.
2. Adam Drozdek, "Data Structures and Algorithms in C++", Brooks and Cole, 2001.
3. Aho, Hopcroft and Ullmann, "Data structures and Algorithm", Addison Welsey,

1984.

MA 501 : Probability, Statistics and Stochastic Processes (3 0 0 6)

Probability : algebra of sets, monotone class, sigma fields, Borel sigma fields, set function, product spaces, measurable transformations, probability measure, notions of probability space and some consequences, Borel-Cantelli Lemma Discrete, continuous and mixed type probability spaces, cumulative distribution functions, probability mass (density) functions, mathematical expectations, general concepts of conditional probability and expectation, conditional expectation given a sigma field, properties of conditional expectation, moments,
moment and probability generating functions, moment inequalities: Markov, Chebyshev-Bienayme, Lyapunov.

Special Probability Distributions : Discrete and continuous uniform, binomial, beta, Cauchy, Negative Binomial, Hypergeometric, Gamma, Normal, Lognormal, Weibull, Pareto distributions, generalized distributions, Approximation properties of discrete distributions, Beta-Binomial and Poisson-Gamma relationship. Function of a random variable, random vectors and their distributions, convolutions, Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bivariate distributions and properties, order statistics and their distributions, further properties.

Sampling Distributions: The Central Limit Theorem, Demoivre theorem, uniform convergence in CLT, characteristics functions, continuity theorems, strong law of large numbers, Sequence of random variables, modes of convergence and some results, Slutsky theorem, distributions of the sample mean and the sample variance for a normal population, Chi - Square, t and F distributions and their distributional properties Point and Interval Estimation : The method of moments and the method of maximum likelihood estimation, large sample properties, concepts of unbiasedness, criteria for choosing estimators, consistency and efficiency of estimates, confidence intervals for the parameters of common distributions, pivotal quantities, confidence intervals for proportions (one and two samples problems) .

Testing of Hypotheses : simple and composite hypothesis, Null and alternative hypotheses, critical and acceptance regions, two types of error, level and size of test, error probabilities of a test, the most powerful test and Neyman - Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for one sample and two sample proportions, Likelihood ratio tests, Chisqaure test for goodness of fit.

Stochastic Processes: illustrations of stochastic processes, stochastic matrices, Markov chains: finite and countably infinite state spaces, Classification of states, strong markov property, stationary distributions, time reversible markov chains, Branching processes, ergodic and nonergodic markov chains, recurrent and transient random walk, General Markov processes in discrete and continuous state spaces. Poisson process: homogeneous and nonhomogeneous, pure birth process, birth and death process, regenerative processes, notions of queuing models

References:

1. Rohatgi, V.K., and Saleh, A.K.Md. Ehsanes (2009). An introduction to probability and statistics. Second Edition, Wiley India.
2. Introduction to the Theory of Statistics; Alexander M. Mood, Franklin A. Graybill, Duane C. Boes, Tata McGraw Hill.
3. Milton, J.S. and Arnold, J.C. (2009) Introduction to Probability and Statistics, Fourth Edition, Tata Mcgraw-Hill.
4. Ross, S.M.(2008) Introduction to Probability Models, Ninth edition, Academis Press.
5. Statistical Inference (2007), G. Casella and R.L. Berger, Duxbury Advanced Series
6. Ash, Robert B. (2009), Probability & Measure Theory, Academic Press

CS 558 Computer Systems Lab – 1 **(0 0 6 6)**

- Basics of OS programming: process creation and synchronization, shared memory and semaphore, shell programming.
- Socket programming, database creation and update, building large client server applications. Basics of compiler writing using lex and yacc

CS 513 Computer Systems Lab-2 **(0 0 6 6)**

- Object-oriented programming concepts and implementation of abstract data types. Implementation of graph algorithms. Linear programming with applications.

Detailed Syllabus for Elective courses - Group-1

CS 561: Artificial Intelligence (3-0-0-6)

Introduction, Problem Solving: Uninformed search, Informed search, local Search, Online search; Knowledge and Reasoning: Building a Knowledge Base, Semantic Nets, Frames, First order logic, Inference in First Order Logic; Probabilistic Reasoning Systems: Bayes' Nets; Learning: Learning from examples and analogy, Naive Bayes, Computational Learning Theory, Explanation Based Learning, Neural Networks; Evolutionary Optimization: Genetic algorithms, Multi objective optimization, Differential Evolution, Particle Swarm Optimization; Introduction to NLP; Introduction to Fuzzy sets.

References:

1. S. Russel and P. Norvig. Artificial Intelligence: A Modern Approach (Second edition), Pearson
2. E. Charniak, Introduction to Artificial Intelligence, Addison Wesley, 1985.
3. P. H. Winston, Artificial Intelligence, Addison Wesley, 1993.
4. E. Rich and K. Knight, Artificial Intelligence, Addison Wesley, 1990.
5. R.Honavar and E. Uhr, Artificial Intelligence and Neural Networks, Academic Press, 1992.
6. F. Hayes Roth, Building Expert Systems, Addison Wesley, 1983.
7. P. R. Cohen, The Handbook of Artificial Intelligence, Vol.1,2 and 3, Kaufman Inc.,1982.
8. B. K. P. Horn, Robot Vision, MIT Press, 1985. J. Carbonell, Machine Learning paradigms and Methods, MIT Press, 1990.

Journals:- Artificial Intelligence, AI Magazine, IEEE Expert, Machine Learning, Computer Vision Image Processing and Graphics, IEEE Transactions on Neural Networks.

CS 542: Software Testing (3 0 0 6)

Testing Background, The Realities of Software Testing, Verification and Validation, Testing Fundamentals, Examining the Specification, Examining the Code, Configuration Testing, Compatibility Testing, Usability Testing, Special Testing Techniques; Test Management, Test Automation and Testing Tools; Recent Trends in Software Testing;

Books:

1. Software Testing by Ron Patton, Sams Publishing
2. Lessons Learned in Software Testing by Kaner, Bach and Pettichord

CS 543 Distributed Systems **(3 0 0 6)**

Basic concepts. Models of computation: shared memory and message passing systems, synchronous and asynchronous systems. Logical time and event ordering. Global state and snapshot algorithms, mutual exclusion, clock synchronization, leader election, deadlock detection, termination detection, spanning tree construction. Programming models: remote procedure calls, distributed shared memory. Fault tolerance and recovery: basic concepts, fault models, agreement problems and its applications, commit protocols, voting protocols, checkpointing and recovery, reliable communication. Security and Authentication: basic concepts, Kerberos. Resource sharing and load balancing. Special topics: distributed objects, distributed databases, directory services, web services.

References:

1. Mukesh Singhal and Niranjan Shivaratri, Advanced Concepts in Operating Systems, McGraw-Hill.
2. Nancy Lynch, Distributed Algorithms, Morgan Kaufmann.
3. Andrew S. Tanenbaum, Distributed Operating Systems, ACM Press.
4. .Jie Wu, Distributed Systems, CRC Press.
5. Hagit Attiya, Jennifer Welch, Distributed Computing: Fundamentals, Simulations and Advanced Topics, McGraw-Hill.
6. Sape Mullender (ed.), Distributed Systems, Addison-Wesley.

MA 511 : Large Scale Scientific Computation **(3 0 0 6)**

Introduction to sparse matrices, Storage Schemes, Permutations and Reorderings, , Sparse Direct Solution Methods. Iterative methos and Preconditioning Convergence Krylov Subspaces, Arnoldi's Method, GMRES, Symmetric Lanczos Algorithm, conjugate Gradient Algorithm, Convergence Analysis, Block Krylov Methods, Preconditioned Conjugate Gradient, Preconditioned GMRES, Jacobi, SOR, and SSOR Preconditioners, ILU Factorization Preconditioners, Block Preconditioners, Types of Partitionings, Techniques, Direct Solution and the Schur Complement, Schur Complement Approaches, Full Matrix Methods, Graph Partitioning: Geometric Approach, Spectral Techniques. Newton's method and some of its variations, Newton method in several dimension, continuation methods, conjugate direction method and Davidon-Fletcher-Powell Algorithms, Introduction to Non-linear Multigrid with applications. HPC kernels (BLAS, multicore and GPU computing)

Texts / References

1. O. Axelsson, Iterative Solution Methods Cambridge Univ. Press, 1994.
2. W. Hackbusch, Multigrid Methods and Applications. Springer-Verlag, 1985.

3. J.M. Ortega and W.C. Rheinboldt, Iterative Solution of Nonlinear Equations in Several Variables. Academic Press, NY, 1970.
4. C.W. Ueberrhuber, Numerical Computation : Methods, Software and Analysis. Springer-Verlag, Berlin, 1997.
5. P. Wesseling, An Introduction to Multigrid Methods. John Wiley & Sons, 1992.
6. Yousef Saad, Iterative Methods for Sparse Linear Systems, SIAM 2003.

CS 528 CAD for VLSI **(3-0-0-6)**

Introduction: VLSI design flow, challenges.
Verilog/VHDL: introduction and use in synthesis, modeling combinational and sequential logic, writing test benches.
Logic synthesis: two-level and multilevel gate-level optimization tools, state assignment of finite state machines.
Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding. Technology mapping.
Testability issues: fault modeling and simulation, test generation, design for testability, built-in self-test.
Testing SoC's.
Basic concepts of verification. Physical design automation.
Review of MOS/CMOS fabrication technology.
VLSI design styles: full-custom, standard-cell, gate-array and FPGA.
Physical design auto-mation algorithms: floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing, Special considerations for analog and mixed-signal designs

References:

1. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design”Springer, 1st edition, 1992.

2. Giovanni De Michelli, “Synthesis and Optimization of Digital Circuits” McGraw-Hill Higher Education, 1994

3. N. A. Sherwani, “Algorithms for VLSI Physical Design Automation”, Bsp Books Pvt. Ltd., 3rd edition, 2005.

Detailed Syllabus for Elective courses - Group-2

CS 548 Wireless Networks (3 0 0 6)

Wireless technologies: Antennas and radio propagation. Signal encoding and modulation techniques. Spread spectrum. Coding and error control.

Wireless Networking: Cellular wireless networks and systems principles. Mobile IP and Wireless Access Protocol. Multiple access techniques.

Wireless LANs: Wireless LAN technology. Wireless standard (IEEE 802.11 etc.). Bluetooth. Ad-hoc Networks. Architectures and routing protocols for hybrid wireless networks, Issues and challenges in wireless sensor networks:

Texts :

1. W. Stallings, "Wireless Communications and Networks", Pearson Education, 2nd Ed.

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. Murthy, "Adhoc Wireless Networks: Architectures and Protocols", Pearson, 2004.
5. Research papers.

CS 549 COMPUTER AND NETWORK SECURITY (3 0 0 6)

Overview: vulnerabilities, risk assessment, incidents.
Cryptography: Classical Cryptography, Symmetric Cryptography, Public Key (Asymmetric cryptography), Modern Cryptography(RSA, ECC), Hash Functions, Digital Signature.

Authentication and Key Management :Entity authentication, Key exchange, Key management, Kerberos
Networking. Security: Security at application layer (PGP, S/MIME), Security at Transport Layer (SSL and TLS), Security at Network Layer (IPSEC)

System Security: Unix Security, Vulnerabilities and Counter Measures (Viruses, worms, Trojan horses, backdoors, buffer overflows, RPC), Exploits (Buffer overflow, Port Scanning etc). Firewalls, VPN etc, Secure (commerce) Transaction over a network.

Current network security Issues:

Texts :

1. W. Stallings, Cryptography and Network Security: Principles and Practice, 5th Ed, Prentice Hall

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.B.A. Foruzan and D. Mukhopadhyay Cryptography and Network Security, second edn.Tata Mchrawhill
4. Related publications in Journals/Conferences.

CS 508: Formal Methods for Analysis and Verification (3 0 0 6)

Introduction to formal methods; Analysis Vs. Verification; Correctness and soundness theorem; Formal semantics: operational, denotational, axiomatic; Specification Languages; Various formal methods and their application to verification and analysis: Model Checking, Abstract Interpretation, Shadow semantics, Hoare logic, Theorem Proving.

References:

1. Flemming Nielson, Hanne R. Nielson, Chris Hankin**.** Principles of Program Analysis, Springer, 1999.
2. Edmund M. Clarke, Orna Grumberg, Doron A. Peled. Model Checking, The MIT Press, 1999.
3. Glynn Winskel. The formal semantics of programming languages: an introduction, The MIT Press, 1993.
4. Annabelle McIver, Carroll Morgan. Abstraction, Refinement and Proof for Probabilistic Systems, Springer, 2005 edition.
6. Recent Research Papers relevant to the course.

CS 502: Pattern Recognition (3 0 0 6)

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 discriminate functions: Principal component analysis, Fisher linear discriminate, 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.

2. S. Theodoridis and K. Koutroumbas , Pattern Recognition, 4th Edition, Academic Press, 2008.

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.

CS 743 Advanced Topics in Database Systems (3-0-0-6)

Database Computation Models: Page and Object Models

Correctness in databases: Serializability - review of the basic theory, multiversion serializability, semantic serializability, relative atomicity, relative serializability, etc.

Concurrency control methods: Two phase locking, timestamp and optimistic methods, tree locking.

Correctness in Software Transactional Memory (STM): Opacity, Virtual Worlds Consistency, Abort Shielded Consistency

Page model crash and recovery: Expanded Schedules, Page-Model Correctness Criteria, Sufficient Syntactic Conditions, Further Relationships Among Criteria, Extending Page-Model CC Algorithms, Redo, undo algorithms

Object model crash and recovery: Unified concurrency control and recovery, compensating transactions, Algorithm for 2-Layered Systems, Algorithm for General Executions

Special Database Systems: Object based, Semi-structured, Active, Deductive, Temporal, Spatial, Multimedia

Database Security: Access Control Models MAC, DAC, RBAC

Datawarehousing: Multidimensional data model, OLAP, Data Warehouse Architecture

This course will draw materials mainly from the books given below. However, there are many research papers that will help understand the course contents. These will be provided on time to time basis.

Suggested Text Books:

1. G. Weikum and G. Vossen – “Transactional Information Systems: Theory, Algorithms and the Practice of Concurrency Control and Recovery”, (Morgan Kaufmann), 2002
2. A. Silberschatz, H. F. Korth and S. Sudarsan – “Database System Concepts”, (McGraw Hill), 2011
3. R. Elamsri, S. B. Navathe – “Fundamentals of Database Systems”, (Pearson Education), 2011
4. R.Kimball – Data Warehouse Toolkit (J.Wiley & Sons), 2nd Edition 2002

Reference Books:

5. P. A. Bernstein, V. Hadzilacos and N. Goodman - Concurrency Control and Recovery in Database Systems, (Addison Wesley), 1987
6. P. A. Bernstein and E. Newcomer – Principles of Transaction Processing, (Morgan Kaufmann), 1997
7. A. Elmagarmid (Ed.)- Database Transaction Models for Advanced Applications, (Morgan Kaufmann), 1992
8. J. Pieprzyk, T. Hardjono and J. Seberry – Fundamentals of Computer Security. (Springer), 2009