# Department of Computer Science and Engineering
# UNIVERSITY OF KALYANI, KALYANI 741235
# WEST BENGAL


## SYLLABUS

## FOR

# MASTER OF SCIENCE (M.Sc.) in COMPUTER SCIENCE
# (Two-Year Programme)

## (Effective from the Session: 2021-22)

Paper Code Convention: MCS-XYZ
[X = 1/2/3/4 (semester), Y = 0/1/2/3 (theory/practical/project/viva), Z (paper id)]

| Semester | Paper Code | Paper Name | Theory/ Practical | Credit | Weekly hours (L+T+P) | Marks Theory - (Exam + Internal Assessment) |
|---|---|---|---|---|---|---|
| Semester-I | MCS – 101 | Advanced Mathematics | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 102 | Algorithms and Data Structure | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 103 | Database Management Systems | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 104 | Operating Systems | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 105 | Computer Organization and Architecture | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 111 | Algorithms and Data Structure Laboratory | Practical | 3 | 0+0+3 | 100 |
| | MCS – 112 | Database Management Systems Laboratory | Practical | 3 | 0+0+3 | 100 |
| | | | Total | 26 | 26 | 700 |
| Semester-II | MCS – 201 | CBCS Open Choice Course | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 202 | Artificial Intelligence | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 203 | Soft Computing | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 204 | Formal Languages and Automata Theory | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 205 | Introduction to Data Analytics | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 211 | Object Oriented Programming Laboratory | Practical | 3 | 0+0+3 | 100 |
| | MCS – 212 | AI and Data Analytics Laboratory | Practical | 3 | 0+0+3 | 100 |
| | MCS – 221 | Review Work & Seminar | Practical | 4 | - | 100 |
| | | | Total | 30 | 26 | 800 |
| Semester-III | MCS – 301 | Computer Networks | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 302 | Compiler Design | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 303 | Software Engineering | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 304 | Elective– I | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 305 | Elective – II | Theory | 4 | 3+1+0 | 100 (80+20) |
| | MCS – 311 | Advanced Programming Laboratory – I | Practical | 3 | 0+0+3 | 100 |
| | MCS – 312 | Advanced Programming Laboratory – II | Practical | 3 | 0+0+3 | 100 |
| | MCS – 321 | Thesis – I | - | 6 | 0+0+6 | 100 |
| | | | Total | 32 | 32 | 800 |
| Semester-IV | MCS – 401 | Elective – III | Theory | 4 | 3+1+0 | 100(80+20) |
| | MCS – 402 | Elective – IV | Theory | 4 | 3+1+0 | 100(80+20) |
| | MCS – 411 | Advanced Programming Lab – III | Practical | 3 | 0+0+3 | 100 |
| | MCS – 421 | Thesis – II | - | 12 | 0+0+20 | 300 |
| | MCS – 431 | Grand Viva Voce | - | 4 | - | 100 |
| | | | Total | 27 | 31 | 700 |
| | | | Overall Total | 115 | 115 | 3000 |

**Elective Papers**

1. Parallel Architecture/Processing and Grid Computing
2. Mobile Computing
3. Real-Time Systems
4. Pattern Recognition
5. High-Performance Computing (HPC)
6. Remote sensing and GIS
7. Web Mining and Internet Technology
8. Computational Biology
9. Management Information Systems
10. Advanced Software Engineering
11. Advanced Network Security
12. Optical Networks
13. Embedded Systems
14. Machine Learning
15. VLSI Technology
16. Speech & Natural Language Processing
17. Theory of Programming Languages/Computing
18. Cloud Computing
19. Authentication & Steganography
20. Computer Graphics
21. Digital Image Processing

* New elective papers may included/offered as per the need of the industry and modern technologies as and when required with the approval of the PG-BoS of Dept. of Computer Science & Engineering.

## Semester I

**Subject Code: MCS - 101**
**Advanced Mathematics, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Optimization Techniques: Linear Programming – Mathematical Model, Graphical Solution, Simplex Method. Integer Programming, Transportation and Assignment Problems.

Combinatorics and Probability: Permutations and Combinations, Mathematical Induction, Probability, Bayes' Theorem. Random Variables and their distributions: Discrete and Continuous.
Group Theory: Groups, Subgroups, Semi Groups, Product and Quotients of Algebraic Structures, Isomorphism, Homomorphism, Automorphism, Rings, Integral Domains, Fields, Applications of Group Theory.
Determinants and Matrices: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Reference Books:
1. Hamdy A. Taha. "Operations Research: An Introduction". Pearson.
2. B.S. Grewal. "Higher Engineering Mathematics". Khanna Publishers.
3. J.L. Mott, A. Kandel and T.P. Baker: Discrete Mathematics for Computer Scientists, Reston, Virginia, 1983.
4. R.A. Brualdi: Introductory Combinatorics, North-Holland, New York, 1977.
5. W. Feller: An Introduction to Probability Theory and its Applications (Volume I and II), 3rd ed. John Wiley, New York, 1973

**Subject Code: MCS – 102**
**Algorithms and Data Structure, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Data Structures Revisited – 1D ,2D and N-D Array, Stack, Queue, Linked Lists.
Graph: Introduction and Definitions. Representation using adjacency matrix, adjacency list. Connected and bi-connected components. Shortest Path. Minimum Cost Spanning Tree. Maximum matching maximum flow.
Tree: Introduction and Definition. Representation of Tree using Linked list. Tree Traversal Techniques. Binary Search Tree, AVL Tree, B Tree, B+ Tree, Red Black Tree.
Algorithms – Analyzing and Designing algorithms – Asymptotic notations – Recurrences – Methods to solve recurrences – Basic sorting techniques – selection sort, bubble sort, insertion sort and merge sort – Basic Search Techniques – linear search and binary search.

Revisiting various operations of different data structures with time complexity analysis – Design and Analysis of Heap Sort - Quick Sort – Sorting in linear time – Radix sort – Selection in linear time.

Design Strategies: Recursion - Divide and conquer methodology – Multiplication of large integers – Strassen's matrix multiplication – Greedy method – Prim's algorithm – Kruskal's algorithm – algorithm for Huffman codes – Dynamic Programming – Backtracking and Branch and bound method.

NP-completeness: Determinism and non-determinism, P, NP, NP-complete, Cook's theorem, Some NP complete problems, Approximation algorithms. Notion of Randomization and Parallelism in algorithms.

Reference Books:

1. T.H.Cormen, C.E.Leiserson, R.L.Rivest and C. Stein, "Introduction to algorithms", 3rd Edition, MIT Press, 2009.
2. P. H. Dave and H. B. Dave, "Design and Analysis of Algorithms", Pearson Education India. 2009.
3. Clifford A. Shaffer, "Practical Introduction to Data Structures and Algorithm Analysis", 2nd Edition, Prentice Hall, 2000.
4. P. Brass, "Advanced Data Structures", Cambridge University Press, 2008.
5. U. Manber: Introduction to Algorithms, Addison-Wesley, 1989.
6. G. Brassard and P. Bartley: Algorithmics: Theory and Practice, Prentice Hall International 1996.
7. A. V. Aho, J. E. Hopcroft and J. D. Ullman: Design and Analysis of Algorithms, Addison-Wesley, 1974
8. M. H. Alsuwaiyel, "ALGORITHMS DESIGN TECHNIQUES AND ANALYSIS", World Scientific Publishing Company Pte. Ltd. 1999.

**Subject Code: MCS – 103**
**Database Management Systems, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction: Database System -– Views– Data Models – Database Languages — Database System Architecture – Database users and Administrator – E-R model – E-R Diagrams -- Introduction to relational databases
Relational model: The relational Model -Keys - Relational Algebra – Domain Relational Calculus – Tuple Relational Calculus - Fundamental operations – Additional Operations- SQL fundamentals - Integrity – Triggers - Security – Advanced SQL features –Missing Information– Views
Database design: Functional Dependencies – Non-loss Decomposition – Functional Dependencies – First, Second, Third Normal Forms, Dependency Preservation – Boyce Codd Normal Form- Multivalued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form
Transactions: Transaction Concepts - Transaction Recovery – ACID Properties – System Recovery – Media Recovery – Two-Phase Commit - SQL Facilities for recovery – Concurrency – Need for Concurrency – Locking Protocols – Two-Phase Locking – Intent Locking – Deadlock- Serializability – Recovery Isolation Levels
Emerging systems: Distributed Databases – Object-oriented Databases - Mobile Databases. XML and Web Databases. Active and Deductive Databases - Multimedia Databases– Multimedia Data Structures – Multimedia Query languages - Spatial Databases.

Reference Books:

1. Ramez Elmasri and Shamkant B. Navathe, "Fundamentals of Database Systems", 4th Edition, Pearson / Addision Wesley, 2007.

2. Thomas Connolly and Carlolyn Begg, "Database Systems, A Practical Approach to Design, Implementation and Management", 3rd Edition, Pearson Education, 2003.
3. Abraham Silberschatz, Henry F. Korth and S. Sudharshan, "Database System Concepts", 5th Edition, Tata McGraw Hill, 2006.

**Subject Code: MCS – 104**
**Operating Systems, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Operating System concepts - OS Structure – OS Services - System Calls. Process management: Process Concept - Operations on process - Cooperating processes- Inter-process communication. Process scheduling - Scheduling algorithms.
Threads- Multithreading models – Containers - Process synchronization- critical-section – Synchronization hardware – Semaphores – Classic problems of synchronization – critical regions.
Deadlocks: Characterization, Prevention, Avoidance, Detection, and Recovery.
Memory Management: Paging, segmentation, Demand Paging, Page Replacement, Allocation of Frames.
File Concepts, Access, and Allocation Methods, Free Space Management. Disk Structure; Disk Scheduling, and Disk Management.
Virtual Machines: Types of Virtual Machines and Implementations; Virtualization.
Linux Operating Systems: Design Principles, Kernel Modules, Process Management, Scheduling, Memory Management, File Systems, Input and Output; Inter-process Communication, Network Structure.
Windows Operating Systems: Design Principles, System Components, Terminal Services and Fast User Switching; File System, Networking.
Distributed Systems: Types of Network based Operating Systems, Network Structure, Communication Structure and Protocols; Robustness, Design Issues, Distributed File Systems.

Reference Books:

1. Abraham Silberschatz, Peter B. Galvin and Greg Gagne, "Operating System Concepts Essentials", John Wiley & Sons Inc., 2010.
2. Andrew S. Tanenbaum, "Modern Operating Systems", 3rd Edition, Prentice Hall, 2007.
3. William Stallings, "Operating Systems: Internals and Design Principles", 7th Edition, Prentice Hall, 2011.
4. Garry Nutt, "Operating Systems", 3rd Edition, Addison-Wesley, 2003.

**Subject Code: MCS – 105**
**Computer Organization and Architecture, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction – Basic Components of Computer Architecture. Stored program concept. Instruction format, Addressing Modes and Instruction Set Architecture. Commonly used number systems. Fixed- and Floating-point arithmetic.
CPU Design – Ripple Carry Adder and Carry Look Ahead Adder design. Multiplication and Division Algorithms. Hardwired and Microprogrammed control. RISC and SISC architecture introduction.
Pipelining – Introduction. Instruction and Arithmetic pipelining. Different Hazards and handling techniques. Pipeline optimization techniques. Vector and Array Processor.
Quantitative techniques in Computer design, measuring and reporting performance.
Memory and IO ¬– Memory organization with CPU-memory interfacing. Cache and Virtual memory organization, mapping and management techniques. Memory replacement policies.
Introduction to parallel processing.

Reference Books:
1. William Stallings, “Computer Organization and Architecture”, 7th Edition, Prentice Hall, 2013.
2. Hennessy J and Patterson D, “Computer Architecture - A Quantitative Approach”, 5th Edition, Morgan Kaufmann, 2011.
3. M. Morris Mano, Michael D. Ciletti, "Digital Design", 4th Edition, Pearson Education, 2011.
4. “Computer Architecture and Parallel Processing” Kai Hwang and A. Briggs International Edition McGraw-Hill.
5. John P Hayes, “Computer Architecture and Organization”, 2nd Edition, McGraw Hill, 2002.
6. Advanced Computer Architectures, Dezso Sima, Terence Fountain, Peter Kacsuk, Pearson.

**Subject Code: MCS – 111**
**Algorithms and Data Structure Laboratory, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**
Lab pertaining to MCS-102

**Subject Code: MCS – 112**
**Database Management Systems Laboratory, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**
Lab pertaining to MCS-103

## Semester II

**Subject Code: MCS – 201**
**CBCS Open Choice Course (For other departments/courses)**
**Introduction to Computing, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

History of Computer, Generation of Computer, Classification of Computers, The Shapes of Computers Today: Supercomputers. Mainframe Computers, Minicomputers, Workstations, Components of a computer, functional units, CPU, memory, types of memory, storage system, input and output devices, working principle of computers, data and information
Data representation, Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASCII. Binary Arithmetic & logic gates

Introduction to Programming, Algorithms and Flow Chart: Generation of programming languages, steps involved in Problem Solving, Algorithm, Flow chat, Pseudo code
Basics of C: A Simple C program, Header files, data types and sizes, Constants, variables, token, identifiers, Operators: arithmetic, relational and logical operators, increment and decrement operators, conditional operator, bit-wise operators, assignment operators; expressions, L-value, rvalue, type conversions, conditional expressions, precedence and order of evaluation, data type conversion, mixed- mode operation, Managing Input and Output operation (formatted and unformatted)
Control Statements: Conditional control statement—if, if-else, nested-if, switch; Goto statement; Looping—while, do-while, for, nested for; jumps in loops—break and continue statement
Arrays: Definition, one-dimensional arrays—declaration and initialization, two—dimensional arrays, multidimensional arrays, dynamic arrays
Strings: Introduction, Declaring and initializing strings, reading and writing strings, String Handling Function, Implementation of string functions, Arithmetic operation on strings, comparison of Strings
Functions: Function definition, arguments and parameters, categories of function, scope and extent, Storage classes, static and register variables, parameter passing mechanism, Inline function, nesting of function, recursion, passing arrays to function, passing strings to function, variable length argument list.
Pointers: Understanding memory address, declaring and initializing pointer variables, void pointer, null pointer, accessing a variable through pointer, array and pointer, pointer and string, pointer as function arguments, Pointer arithmetic, pointers to pointer, function returning pointer , pointers and structure, Dynamic memory allocation (Malloc, Calloc, releasing the used space, Realloc), Memory leak and memory corruption.
User defined data: Structure- defining, declaring, initializing; accessing structure members, processing of structure , array of structures, structures within structure, structure and function, type definition; Union—definition, declaration, accessing union members , initializing union Types
Pre-processor: Introduction, macro substitution, File Inclusion, Compiler control Directives 1
Files: Introduction, file declaration, opening and closing a file, working with text and binary files, I/O operations on file, error handling, random access to files

**Suggested books**

1. V. Rajaraman, Fundamentals of Computers, Edition 6, PHI, 2014.
2. V. Rajaraman, Computer Basics and C Programming, PHI, August 2008.
3. E. Balagurusamy, Programming in ANSI C, Edition 7, McGrawHill, August 2016.

**Subject Code: MCS - 202**
**Artificial Intelligence, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction – What is AI – Importance of AI – objectives.
Intelligent agents, state space representation, uninformed searches – BFS, DFS, IDS, informed and heuristic searches – Branch & bound, Best first, A* search; Local searches
and optimization, local and global optima, hill climbing, gradient descent, simulated annealing, genetic algorithms, Adversarial Search: Min-Max game tree
Knowledge – Its representation, Organization – Manipulation and Acquisition.

Predicate calculus in AI – First order predicate logic & its use in knowledge representation-Resolution principle. Use of resolution in reasoning and question answering.
Uncertainly Management-Fuzzy logic, Bayesian inferencing, dempster-shafer theory of beliefs, structured representation of knowledge- - Semantic networks, frames, conceptual dependency & scripts. Expert systems-rule based system architecture non-production system architecture-knowledge acquisition methods-Explanation methods-Expert system shells, Application of AI in natural language processing, speech understanding. Computer Vision, planning, etc.

Book:

1. Introduction to Artificial Intelligence and Expert Systems by D.W. Patterson.
2. Artificial Intelligence: A Modern Approach - 3rd edition by Stuart Russell & Peter Norvig.
3. Artificial intelligence by Elaine Rich & Kevin Knight.
4. Principles of Artificial Intelligence by J. Nilsson, Narosa Publishing House.

**Subject Code: MCS – 203**
**Soft Computing, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction: Introduction to soft computing; introduction to biological and artificial neural network; introduction to fuzzy sets and fuzzy logic systems.
Introduction to Genetic Algorithm, Genetic Operators and Parameters, Genetic Algorithms in Problem Solving, Theoretical Foundations of Genetic Algorithms, Implementation Issues.
Artificial neural networks and applications: Different artificial neural network models; learning in artificial neural networks; neural network applications in control systems. Neural Nets and applications of Neural Network.
Fuzzy systems and applications: fuzzy sets; fuzzy reasoning; fuzzy inference systems; fuzzy control; fuzzy clustering; applications of fuzzy systems.
Neuro-fuzzy systems: neuro-fuzzy modeling; neuro-fuzzy control.
Applications: Pattern Recognitions, Image Processing, Biological Sequence Alignment and Drug Design, Robotics and Sensors, Information Retrieval Systems, Share Market Analysis, Natural Language Processing.

**Text Books:**
1. M. Mitchell: An Introduction to Genetic Algorithms, Prentice-Hall.
2. J.S.R.Jang, C.T.Sun and E.Mizutani: Neuro-Fuzzy and Soft Computing, PHI, Pearson Education.
3. Timothy J.Ross: Fuzzy Logic with Engineering Applications, McGraw-Hill.
4. Davis E.Goldberg: Genetic Algorithms: Search, Optimization and Machine Learning, Addison Wesley.

**Reference Books:**
1. S. Rajasekaran and G.A.V.Pai: Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI.
2. D. E. Goldberg: Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley.

**Subject Code: MCS - 204**
**Formal Languages and Automata Theory, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction: Symbols, Strings, Alphabets and Languages. Set Properties. Kleen's Star. Chomsky Hierarchy.
Regular Language and Finite Automata: Introduction to Finite Automata. DFA definition and construction. NFA definition and construction. DFA vs NFA. Conversion. Introduction to regular language and expression. Closure Properties. Pumping Lemma. Construction of automata from regular expression and vice versa. DFA reduction. Regular grammar.
Context Free Language and Push Down Automata: Definition and construction of PDA. DPDA vs NPDA. Context Free Language and Grammar. Closure properties. Parse trees and Ambiguity. Reduction. Normal Forms.
Context Sensitive Language and Linear Bounded Automata: Introduction and Definition.
Turing Machine: Unbounded Languages. Introduction to Turing Machine. Definition and construction of Turing Machine. Single and Multi-tape TM. Parameter theorem, Diagonalisation, Reducibility, Rice's Theorem and its applications. Church Turing Thesis. Universal Turing Machine. Halting Problem.
Overview of Computational Complexity and Different Complexity Classes.

Reference Books:
1. Peter Linz. "An Introduction to Formal Languages and Automata". Narosa.
2. Daniel I.A.Cohen, "Introduction to computer theory". John Wiley,1996
3. Lewis & Papadimitriou, "Elements of the theory of Computation". PHI 1997.
4. Hoperoft, Aho, Ullman, "Introduction to Automata theory, Language & Computation" 3rd Edition.Pearson Education. 2006
5. N. J. Cutland: "Computability: An Introduction to Recursive Function Theory", Cambridge University Press, London, 1980.

**Subject Code: MCS – 205**
**Introduction to Data Analytics, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction to Data Analytics; Descriptive Statistics: Introduction to Descriptive Statistics, Probability Distributions. Inferential Statistics: Inferential Statistics through hypothesis tests Permutation & Randomization Test. Regression & ANOVA Regression ANOVA (Analysis of Variance)
Machine Learning: Introduction and Concepts Differentiating algorithmic and model based frameworks.
Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification
Supervised Learning with Regression and Classification techniques: Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines
Ensemble Methods: Random Forest Neural Networks Deep learning
Unsupervised Learning and Challenges for Big Data Analytics: Clustering Associative Rule Mining Challenges for big data anlalytics

Prescriptive analytics: Creating data for analytics through designed experiments, Creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning

Books:

1. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
2. Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers. John Wiley & Sons, 2010

**Subject Code: MCS – 211**
**Object Oriented Programming Laboratory, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Lab on Object Oriented Programming using C++/Java

**Subject Code: MCS – 212**
**AI and Data Analytics Laboratory, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Lab pertaining to MCS-202, MCS-203 and MCS-205

**Subject Code: MCS – 221**
**Review Work & Seminar, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Review work on Literature leading to project and seminar presentation.

## Semester III

**Subject Code: MCS - 301**
**Computer Networks, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction: Computer networks and distributed systems, classifications of computer networks, layered network structures.
Data Communication Fundamentals: Channel characteristics, various transmission media, different modulation techniques.
Queuing Theory: M/M queuing systems, M/G/I queuing system; Network performance analysis using queuing theory.

Network Structure: Concepts of subnets, backbone and local access; Channel sharing techniques- FDM, TDM; Polling and concentration, message transport: circuit, message and packet switching, topological design of a network.
Data Link Layers: Services and design issues, framing techniques, error handling and flow control, stop and wait, sliding window and APRPANET protocols, HDCLC standard.
Network Layer: Design issues, internal organization of a subnet, routing and congestion control techniques, network architecture and protocols, concepts in protocol design, CCITT recommendation X. 25
LANs and their Interconnection: Basic concepts, architectures, protocols, management and performance of Ethernet, token ring and token bus LANS; Repeaters and Bridges.
Internet: IP protocol, Internet control protocols— ICMP, APR and RAPP, Internet routing protocols— OSPF, BGP and CIDR.
ATM: ATM switches and AAL layer protocols.
Network Security: Electronic mail, directory services and network management.
Wireless and mobile communication: Wireless transmission, cellular radio, personal communication service, wireless protocol. Network planning, Gigabit and Terabit technology, CDMA, WCDMA, WDM, optical communication networks.

Reference Books:

1. A. Tannenbaum: Computer Networks, 3rd ed., Prentice Hall India, 1996.
2. W. Stallings: ISDN and Broadband ISDN with Frame Relay and ATM, Prentice Hall, Englewood Cliffs, 1995.
3. W. Stallings: Local and Metropolitan Area Networks, 4th ed., Macmillan, New York, 1993.
4. Kaufman, R. Perlman and M. Speciner: Network Security, Prentice Hall, Englewood Cliffs, 1995.
5. V. P. Ahuja: Design and Analysis of Computer Communication Networks, McGraw Hill, New York, 1987.
6. L. Gracial and I. Widjaja: Communication Networks, Tata-McGraw Hill, New Delhi, 2000.
7. L. L. Paterson and B. S. Davie: Computer Network, Morgan Kaufman, San Mateo, 2000.

**Subject Code: MCS - 302**
**Compiler Design, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Introduction to Compiling: Compilers, Analysis-synthesis model, The phases of the compiler, Cousins of the compiler.
Lexical Analysis: The role of the lexical analyser, Tokens, Patterns, Lexemes, Input buffering, Specifications of a token, Recognition of tokens, Finite automata, From a regular expression to an NFA, From a regular expression to NFA, From a regular expression to DFA, Design of a lexical analyser generator (Lex).
Syntax Analysis: The role of a parser, Context free grammars, writing a grammar, Top down Parsing, Non-recursive Predictive parsing (LL), Bottom up parsing, Handles, Viable prefixes, Operator precedence parsing, LR parsers (SLR, LALR), Parser generators (YACC). Error Recovery strategies for different parsing techniques.

Syntax directed translation: Syntax directed definitions, Construction of syntax trees, Bottom-up evaluation of S attributed definitions, L attributed definitions, Bottom-up evaluation of inherited attributes.
Type checking: Type systems, Specification of a simple type checker, Equivalence of type expressions, Type conversions
Run time environments: Source language issues (Activation trees, Control stack, scope of declaration, binding of names), Storage organization (Subdivision of run-time memory, Activation records), Storage allocation strategies, Parameter passing (call by value, call by reference, copy restore, call by name), Symbol tables, dynamic storage allocation techniques.
Intermediate code generation: Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples).
Code optimization: Introduction, Basic blocks & flow graphs, Transformation of basic blocks, Dag representation of basic blocks, The principle sources of optimization, Loops in flow graph, Peephole optimization.
Code generations: Issues in the design of code generator, a simple code generator, Register allocation & assignment.

Reference books:

1. Aho, Sethi, Ullman - “Compiler Principles, Techniques and Tools” - Pearson Education.
2. Holub - “Compiler Design in C” – PHI
3. Tremblay and Sorenson – “Compiler Writing”. McgrawHill International.
4. Chattopadhyay S. – “Compiler Design” –PHI

**Subject Code: MCS - 303**
**Software Engineering, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Software Engineering – Objectives, Definitions, Software Process models - Waterfall Model, Prototyping, RAD, Evolutionary Models, Incremental, Spiral. Software Project Planning- Feasibility Analysis, Technical Feasibility, Cost- Benefit Analysis, COCOMO model.
Structured Analysis, Context diagram and DFD, Physical and Logical DFDs, Data Modelling, ER diagrams, Software Requirements Specification
Design Aspects: Top-Down and Bottom-Up design; Decision tree, decision table and structured English, Structure chart, Transform analysis Functional vs. Object- Oriented approach.
UML: Class diagram, interaction diagram: collaboration diagram, sequence diagram, state chart diagram, activity diagram, implementation diagram.
Coding & Documentation – Structured Programming, Modular Programming, Module Relationship-Coupling, Cohesion, OO Programming, Information Hiding, Reuse, System Documentation.
Testing – Levels of Testing, Integration Testing, System Testing.
Software Quality, Quality Assurance, Software Maintenance, Software Configuration Management, Software Architecture.

Reference Books:
1. Software Engineering: A practitioner’s approach– Pressman(TMH)
2. Software Engineering: Pankaj Jalote (Wiley-India)
3. Software Engineering: Rajib Mall (PHI)

4. Software Engineering: Agarwal and Agarwal (PHI)

**Subject Code: MCS - 304**
**Elective I, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Elective paper to be chosen from the pool of electives.

**Subject Code: MCS - 305**
**Elective II, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Elective paper to be chosen from the pool of electives.

**Subject Code: MCS – 311**
**Advanced Programming Laboratory-I, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Lab on advanced programming based on theoretical papers and electives.

**Subject Code: MCS – 312**
**Advanced Programming Laboratory-II, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Lab on advanced programming based on theoretical papers and electives.

**Subject Code: MCS – 321**
**Thesis-I**

Thesis Work - I

## Semester IV

**Subject Code: MCS - 401**
**Elective III, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Elective paper to be chosen from the pool of electives.

**Subject Code: MCS - 402**

**Elective IV, Weekly Hours: 3 + 1 + 0**
**Allotted Hrs: 40L**

Elective paper to be chosen from the pool of electives.

**Subject Code: MCS – 411**
**Advanced Programming Laboratory-III, Weekly Hours: 0 + 0 + 3**
**Allotted Hrs: 40P**

Lab on advanced programming based on electives.

**Subject Code: MCS – 421**
**Thesis-II**

Thesis Work – II

**Subject Code: MCS – 431**
**Grand Viva**

## Elective Papers

**Elective: Parallel Architecture/Processing and Grid Computing**

Parallel computer models: Multiprocessors and Multicomputer – Multifactor and SIMD computer PRAM & VLSI models, conditions of parallelism. System interconnect architectures performance. Metrics and Measures.
Advanced processor technology – Super scalar and vector processors – Memory hierarchy technology, virtual memory technology – cache memory organization – shared – memory organization.
Linear pipeline processors – Nonlinear pipeline processors – Instruction pipeline design, Arithmetic pipeline design – Superscalar pipeline design.
Multiprocessor system interconnects – Cache coherence, Vector processing principle
Compound Vector processing, SIMD computer organization, multiprocessor operating system, multiprocessor examples.
Grid Computing values and risks – History of Grid computing – Grid computing model and protocols – overview of types of Grids.
Desktop Grids: Background – Definition – Challenges – Technology – Suitability – Grid server and practical uses; Clusters and Cluster Grids; HPC Grids; Scientific in sight – application and Architecture

– HPC application development environment and HPC Grids; Data Grids; Alternatives to Data Grid – Data Grid architecture.
The open Grid services Architecture – Analogy – Evolution – Overview – Building on the OGSA platform – implementing OGSA based Grids – Creating and Managing services – Services and the Grid – Service Discovery – Tools and Toolkits – Universal Description Discovery and Integration (UDDI)
Desktop supercomputing – parallel computing – parallel programming paradigms – problems of current parallel programming paradigms – Desktop supercomputing programming paradigms – parallelizing existing applications – Grid enabling software applications – Needs of the Grid users – methods of Grid deployment – Requirements for Grid enabling software – Grid enabling software applications.

**Reference Books:**

1. Kai Hwang, "Advanced Computer Architecture", Parallelism, Scalability, Programmability, McGraw Hill, 1993.
2. Ahmar Abbas, "Grid Computing, A Practical Guide to Technology and Applications", Firewall media, 2004.
3. Hwang Briggs, "Computer Architecture and parallel processing", McGraw hill.
4. William Stallings, "Computer Organization and Architecture- Designing for Performance", PHI, 2000.
5. Joshy Joseph, Craig Fellenstein, "Grid Computing", Pearson Education, 2004.
6. Foster, "Grid Blue print foe new computing".

**Elective: Mobile Computing**

Wireless Transmission –Wired and wireless, Mobility of users and equipment, Electromagnetic Spectrum, Radio and Microwave communication, Infrared and Millimeter waves, Length-wave Transmission.
Satellite Network Architecture – Satellite Orbits-GEO LEO, MEO. Inmarsat, Iridium, Odyssey, Global Star Archimedes and other Satellite Networks.
Spread Spectrum and CDMA – Direct (pseudo-noise) and Frequency hopped Spread Spectrum. CDMA System.
Wireless LANs – MACA and MACAW protocols. Infrared LAN. Cellular Radio Systems-Paging, Cordless telephones, Analog Cellular telephones AMPS. Digital Cellular Telephone-GSM. Personal Communication service (PCS).
CDPD system.
Mobile Data Networks and their applications.
Wireless and Mobile access to the Internet.

**Reference Books:**

1. V. K. Garg & J. E. Wilks: Wireless and Personal Communication Systems: Fundamentals and Applications IEEE Press and Prentice Hall, 1996.

2. T. S. Rappaport, B. D. Werner and J. H. Reed: Wireless Personal Communications: The Evolution of PCS, Dkyener Academic, 1996.
3. G. I. Stuber: Principles of Mobile Communication, Kluener Academic, 1996.
4. U. Black: Mobile and Wireless Networks, Prentice Hall PTR, 1996.

**Elective: Real-Time Systems**

Real Time Systems, Specification, Analysis, Design. Definition, Types and Evolution; State Diagram, Finite Automata, Timed Petri Net, Formal Methods for Analysis & Design. Algorithm Development, Implementation of Real Time Algorithms Debugging and Verification Real Time Distributed Computing

Clock Synchronization, Real Time constraint satisfaction Reliability & Safety.

Case Studies Computer Control Systems Real Time Simulation Systems

Mission Control Systems Safety Critical Systems.

**Reeference Books:**

1. Real-time Systems, Jane W. S. Liu
2. Real-Time Systems Design and Analysis, Philip A. Laplante
3. Real-time Systems, Hermann Kopetz
4. Real-time Systems: Theory and practice, Rajib Mall
5. Real-Time Concepts for Embedded Systems, Caroline Yao, Li Zhang

**Pattern Recognition**

Bayes' Decision Theory, Discriminant functions and decision procedures, Relaxation procedures, Non-separable behavior.
Parameter estimation and supervised learning, Maximum likelihood estimation, Sufficient statistics, Problems of dimensionality, Nom [Ara, etroc techniques, density estimates, Parzen Windows, k-nearest neighbor estimation, Fisher's linear discriminate.
Clustering and unsupervised learning, Cluster validity, hierarchical and graph theoretic methods, Sealing. Feature Selection-Karhunen Loeve, Stochastic approximation, kernel approximation, divergence measures.
Syntactic Pattern Recognition, Inductive Learning, Grammatical Inference, Error correcting Parsing, Vapnik - Chorvononkis result.

**Reference Books:**

1. Tou & Gonzalez: Principles of Pattern Recognition, Addison Wesley.
2. B. D. Ripley: Pattern Recognition & Neural Networks, Cambridge University Press.
3. Tou & Gonzalez: Syntactic Pattern Recognition, Addison Wesley.
4. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.

**Elective: High-Performance Computing (HPC)**

Parallel Processing Concepts (Quick Overview): Levels of parallelism (instruction, transaction, task, thread, memory, function). Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc). Architectures: N-wide superscalar architectures, multi-core, multi-threaded

Parallel Programming with CUDA: Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Microarchitecture and Intel Nehalem microarchitecture). Memory hierarchy and transaction specific memory design. Thread Organization

Fundamental Design Issues in Parallel Computing: Synchronization. Scheduling. Job Allocation. Job Partitioning. Dependency Analysis. Mapping Parallel Algorithms onto Parallel Architectures. Performance Analysis of Parallel Algorithms.

Fundamental Limitations Facing Parallel Computing: Bandwidth Limitations. Latency Limitations. Latency Hiding/Tolerating Techniques and their limitations

Power-Aware Computing and Communication: Power-aware Processing Techniques. Power-aware Memory Design. Power-aware Interconnect Design. Software Power Management

Advanced Topics: Petascale Computing. Optics in Parallel Computing. Quantum Computers. Recent developments in Nanotechnology and its impact on HPC

**Reference Books:**


1. "Highly Parallel Computing", by George S. Almasi and Alan Gottlieb
2. "Advanced Computer Architecture: Parallelism, Scalability, Programmability", by Kai Hwang, McGraw Hill 1993.
3. "Parallel Computer Architecture: A hardware/Software Approach", by David Culler Jaswinder Pal Singh, Morgan Kaufmann, 1999.
4. "Scalable Parallel Computing", by Kai Hwang, McGraw Hill 1998.
5. "Principles and Practices on Interconnection Networks", by William James Dally and Brian Towles, Morgan Kauffman 2004.
6. GPU Gems 3 --- by Hubert Nguyen (Chapter 29 to Chapter 41).
7. Introduction to Parallel Computing, Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, 2nd edition, Addison-Welsey, © 2003.
8. Petascale Computing: Algorithms and Applications, David A. Bader (Ed.), Chapman & Hall/CRC Computational Science Series, © 2007.


**Elective: Remote sensing and GIS**

Introduction: Sun and atmosphere, Remote Sensing a historical perspective.
Electromagnetic Radiations: EM radiators, polarization, attenuation.
Thermal radiations, EM for remote sensing.
Fundamental of Radiometry.
Physical Basics of Signatures: Signature OIR, TIR & Microware Region
Remote Sensor: Classifications of Sensors, Sensor parameters.
Resolution- Spatial & Spectral
Optical, Microwave Sensors
Platform: Principle of Sattelite Motion, Types of orbit, Orbit perturbations.
GPS – Data Products: Dataformats, data product generation output media
Date analysis: Visual analysis, Digital Classifications
Application of Remote Sensing: Agriculture, Forestry, Land Cover Studies
Water Resource, Earth System Science
Geographical Interaction System Application.

**Reference Books:**

1. "Principles of geographical information systems", P. A. Burrough and R. A. Mcdonnel, Oxford.
2. "Remote sensing of the environment", J. R. Jensen, Pearson
3. "Exploring Geographic Information Systems", Nicholas Chrismas, John Wiley & Sons.
4. "Getting Started with Geographic Information Systems",Keith Clarke, PHI.
5. "An Introduction to Geographical Information Systems", Ian Heywood, Sarah Cornelius, and Steve Carver. Addison-Wesley Longman.

**Elective: Web Mining and Internet Technology**

Data integration for e-commerce, Web personalization and recommender systems, Web content and structure mining, Web data warehousing, Review of tools, applications, and systems, Data collection and sources of data, Data preparation for usage mining, Mining navigational patterns, Integrating e-commerce data, Leveraging site content and structure, User tracking and profiling.

E-Metrics: measuring success in e-commerce, Privacy issues, Evolution of the Internet, Growth of the World Wide Web and Big Data, Client-server model, Architecture of the Intranet/Internet/Extranet, Access method: dialup, ISDN, ADSL/2+, cable, LAN, WiFi, Mobile and Satellite, Proxy Servers, Application areas: E-commerce, Education, Entertainment such as Games and Gambling

Internet of Things (IoT) Search Engines, Webbots, integrity of information, database online.

**Reference Books:**

1. Presten Gralla and Michael Troller., How the Internet Works, Que, (8th Edition), 2006
2. Perry J. et al, The Internet – Illustrated Introductory, Course Technology (3rd Ed)
3. Bates, C., Web Programming: Building Internet Applications, John Wiley and Sons (3rd Ed), 2006.
4. Berners-Lee, T. et al, Weaving the Web, Harper Business, 2000
5. Hofstetter, F.T., Internet Literacy, McGraw Hill (4th Ed), 2005
6. McGloughlin, S., Multimedia: Concepts and Practice, Prentice Hall, 2001.
7. Anderson, P., Web 2.0 and Beyond: Principles and Technologies, Chapman & Hall/CRC Textbooks in Computing, 2012
8. Bahga, A and Madisetti, V., Internet of Things: A Hands-On Approach, VPT, 2014

**Elective: Computational Biology**

Introduction to molecular biology, cell, chromosome, DNA, RNA, proteins, Central Dogma, protein structures, computational biology and bioinformatics tasks;
Sequence databases,sequence comparison, sequence alignment, local and global sequence alignment, multiple sequence alignment, web tools for sequence comparisons;
Sequencing, genome sequencing, fragment assembly, next-generation sequencing, handling errors in sequencing, gene finding, promoter identification, sequence-based protein classification;
Protein structures, structure prediction from sequence, motif finding, structure alignment, structure-based protein classification, molecular design and docking;

Phylogeny analysis, phylogenetic tree construction algorithms, parsimony and distance-based techniques;
Gene expression analysis, microarray, microarray analysis, differential expression, microarray clustering,biclustering, classification, gene marker prediction, gene selection, gene ordering, gene prioritization, gene significance analysis, gene co-expression, differential co-expression;
Biological networks, protein-protein interactions, gene regulatory networks, metabolic networks, network analysis and prediction, systems biology;
Biological databases, sequence databases, gene/protein databases, protein structure/domain databases, microarray gene expression databases, protein-protein interaction databases, gene regulatory network databases, metabolic network databases.

**Text Books:**

1. Carlos Setubal and Joao Meidanis, "Introduction to Computational Molecular Biology", Brooks/Cole.

**Reference Books:**

1. Molecular Cell Biology by DaidBaltimar
2. Aurther M. Lesk, Introduction to Bioinformatics, Oxford University Press, 4th edition (2014)
3. Dan E. Krane and Michael L. Raymer, Fundamental Concepts of Bioinformatics Krane and Raymer, DORLING KINDERSLEY (RS); First edition (2003)
4. David Mount : Bioinformatics: Sequence and Genome Analysis, CBS; 2 edition (2005)

**Elective: Management Information Systems**

Management activities, roles and levels
Management Planning and Control: how planning and control systems interrelate
Strategic Planning within an organization: activities, techniques and results
The nature of decision-making: decision-making models and classification of decision-making situations
Management as the direct user of an MIS vs Intermediary usage
Measurement of MIS performance and capabilities
Reporting Systems (MRS), Decision Support Systems (DSS), Office Information Systems (OIS) – including video conferencing and email
Knowledge based systems that support management such as Expert Systems (ES) and Neural Network (NN) Systems
The application of Online-Analytical Processing (OLAP)/Data Mining/Business Intelligence (BI) tools in supporting management decision making
The relationships of MIS to other enterprise applications, such as Transaction Processing Systems (TPS) and Enterprise Resource Planning (ERP) systems
IS within functional areas such as Human Resources, Marketing and Sales, Production, Accounting and Finance, Customer Relationship Management (CRM), Product Supply Chain Management Systems
The Internet and MIS provisions: Internet and the linkages to legacy MIS, Internet customer interfaces, security issues, MIS and mobile computing, MIS and social media

**Reference Books:**

1. Kenneth C. Laudon & Jane P. Laudon, Essentials of Management Information Systems, Tenth Edition, Pearson Prentice-Hall, 2012
2. Terry Lucy, Management Information Systems, Ninth Edition, 2005, Thompson

3. McNurlin, Sprague & Bui, Information Systems Management in Practice, Prentice-Hall (8th Ed), 2013
4.Efraim Turban, Jay Aronson & Tin-Peng Liang, Decision Support Systems and Intelligent Systems, Ninth Internal Edition, Pearson Prentice Hall, 2010.

**Elective: Advanced Software Engineering**

System Engineering - Analysis & Design, Software Architectures & Design, Software Metrics.
Software Testing Strategies: Analytical models (e.g. Markov Chain Model, Probabilistic Models)
Software Reliability: Analytical Models.
Formal Methods in Software Engineering (e.g. Formal Specification Language)
Software Re-use, Re-engineering - reverse engineering.
Real-time Software Engineering, Client/Server Software Engineering.
CASE tool design & implementation, Verification & Validation.
Object-oriented Software Engineering: OO-Analysis, OO-Design, OO-Testing, metrics for OO systems.
System Modeling and Simulation, Software Engineering Economics.

**Reference Books:**

1. Pressman: Software Engineering, McGraw Hill.
2. Shoeman: Software Engineering, McGraw Hill.
3. Ghezzi, Software Engineering, PHI
4. Fundamentals of Software Engineering by Rajib Mall, PHI.
4. Sommerville, Ian – Software Engineering, Pearson Education

**Elective: Advanced Network Security**

Uniqueness – Number Theory concepts – Primality – Modular Arithmetic – Fermet & Euler Theorem – Euclid Algorithm – RSA – Elliptic Curve Cryptography – Diffie Hellman Key Exchange.

Digests – Requirements – MAC – Hash function – Security of Hash and MAC – Birthday Attack – MD5 –SHA – RIPEMD – Digital Signature Standard – Proof of DSS Authentication applications – Kerberos – Kerberos Encryption Techniques – PGP – Radix64 – IP Security Architecture – Payload – Key management – Web security requirements – SSL – TLS – SET

Resources – Intruders and Intrusion – Viruses and Worms – OS Security – Firewalls – Design Principles – Packet Filtering – Application gateways – Trusted systems – Counter Measures Protocols and standards – OSI model – TCP / IP protocol suite – addressing – versions – underlying technologies.

Classful addressing – other issues – subnetting – supernetting – classless addressing – routing methods – delivery – table and modules – CIDR – ARP package – RARP.

Datagram – fragmentation – options – checksum – IP package – ICMP – messages, formats – error reporting – query – checksum – ICMP package – IGMP – messages, operation – encapsulation – IGMP package – UDP – datagram – checksum – operation – uses – UDP package.

Services – flow, congestion and error control – TCP package and operation – state transition diagram – unicast routing protocols – RIP – OSPF – BGP – multicast routing – trees – protocols – MOSPF – CBT – PIM

Client server model – concurrency – processes – sockets – byte ordering – socket system calls – TCP and UDP client-server programs – BOOTP -DHCP – DNS – name space, resolution – types of records – concept – mode of operation – Rlogin.

**Reference Books:**

1. "Network Security Essentials: Applications and Standards" by William Stallings, Pearson
2. "Network Security private communication in a public world", C. Kaufman, R. Perlman and M. Speciner, Pearson
3. "Cryptography and Network Security", William Stallings, 2nd Edition, Pearson Education Asia
4. "Designing Network Security", Merike Kaeo, 2nd Edition, Pearson Books
5. "Building Internet Firewalls", Elizabeth D. Zwicky, Simon Cooper, D. Brent Chapman, 2nd Edition, Oreilly
6. "Practical Unix & Internet Security", Simson Garfinkel, Gene Spafford, Alan Schwartz, 3rd Edition, Oreilly

**Elective: Optical Networks**

Introduction to Optical Networks

Components

Transmitters

Transmission System Engineering

First Generation Networks

Wavelength Routing Networks

Virtual Topology Design

Access Networks

**Reference Books**:

1. Optical networks: A practical perspective, Kumar Sivarajan and Rajiv Ramaswamy: Morgan Kauffman 1998.
2. Gigabit-capable Passive Optical Networks-D. Hood, Wiley
3. Optical Communication Networks: Biswajit Mukherjee: TMG,1998.
4. Optical Networks, Ulysees Black: Pearson education 2007.

**Elective: Embedded Systems**

Software Technology – Software Architectures, Software development Tools, Software Development Process Life Cycle and its Model, Software Analysis, Design and Maintenance.

Introduction To Data Representation – Data representation, Two's complement, Fixed point and Floating Point Number Formats, Manipulating Bits in Memory, I/O Ports, Low level programming in C, Primitive data types, Arrays, Functions, Recursive Functions, Pointers, Structures & Unions, Dynamic Memory Allocation, File handling, Linked lists, Queues, Stacks

Mixing C and Assembly – C and assembly, Programming in assembly, Register Usage Conventions, Typical use of Addressing Options, Instruction Sequencing, Procedure Call and Return , Parameter passing ,Retrieving Parameters , Everything in pass by value ,Temporary variables.

Input/output Programming – I/O Instructions, Synchronization, Transfer Rate & Latency, Polled Waiting Loops, Interrupt – Driven I/O, Writing ISR in Assembly and C, Non-Maskable and Software Interrupts

Memory Management – Direct Memory Access, Local and Global Scope, Automatic and Static Allocation, Distinguishing Static from Automatic Object Creation, Initialization and Destruction, Dynamic Allocation

Unified Modeling Language**:-** UML basics, Object state behavior - UML state charts - Role of scenarios in the definition of behavior - Timing diagrams - Sequence diagrams - Event hierarchies - types and strategies of operations - Architectural design in UML concurrency design - threads in UML

Software Tools: - DJGPP C/C++ compiler, linker, loader and utilities, The ASM assembler, µCOS-II Preemptive Kernel, Multi C Non-Preemptive Kernel

**Text Books:**

1. Daniel W. Lewis, "Fundamentals of embedded software where C and Assembly meet", Pearson Education
2. Bruce Powel Douglas, "Real time UML, second edition (The Addison Wesley Object technology series)", 2nd edition 1999, Addison Wesley
3. Hassan Gomma, "Designing concurrent, distributed, and real time application with UML", Pearson Education, 2000
4. Albert M. K. Cheng, "Real-time systems: scheduling, analysis and verification", Wiley

**Elective: Machine Learning**

Advanced clustering methods, variants of K-means, higherarchical clustering, BIRCH, DBSCAN, Expectation-Maximization, Cluster Evaluation Techniques – Internal and External, clustering ensemble.
Linear Discriminant Analysis, Support Vector Machine, Naïve Bayes, Gradient Descent, Class Evaluation Measures, Overfitting, Bias Variance Trade-off Precision, Recall, F1 Score, ROC, AUC, Validation Strategies.

Neural Network, LTU, Perceptron, MLP, Activation Function, Loss Functions, Optimizers, Momentum Adadelta, RMSProp, Adam, Early Stopping, drop-out, Batch Normalization; Word Embedding, CboW, Skip-gram, Glove, ElMo, CNN, RNN, LSTM, GRU, Encoder-Decoder Network, Transfer, Auto Encoder, Generative Adversarial Network; Ensemble Methods - Bagging, Committee Machines and Stacking, Ensemble Methods – Boosting, Gradient Boosting; Undirected Graphical Models, Markov Chains, Random walk Monte Carlo, HMM, Variable elimination, belief propagation, Introduction to Reinforcement Learning, Sampling-based techniques, Q Learning, Introduction to XAI, Lime, SHAP etc. Learning from online streaming data, Machine Learning Applications.

**Text Books:**


1. Tom Mitchell, Machine Learning, McGraw Hill,1997.
2. Duda, Richard O., Peter E. Hart, and David G. Stork. *Pattern classification*. John Wiley & Sons, 2012.
3. Alpaydin, Ethem. *Introduction to machine learning*. MIT press,2009.
4. Friedman, Jerome,Trevor Hastie,and Robert Tibshirani. *The elements of statistical learning*. Vol.
   1. No. 10. New York: Springer series in statistics,2001.
5. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. MIT Press2012.
6. Ian Goodfellow, Yoshua Bengio and Aaron Courville. Deep Learning. MIT Press2016.


**Elective: VLSI Technology**

Introduction on VLSI Design, Bipolar Junction Transistor Fabrication, MOSFET Fabrication for IC

Crystal Structure of Si, Crystal Structure contd, Defects in Crystal + Crystal growth, Crystal growth Contd + Epitaxy I

Epitaxy II - Vapour phase Epitaxy, Epitaxy III - Doping during Epitaxy, Molecular beam Epitaxy

Oxidation I - Kinetics of Oxidation, Oxidation II Oxidation rate constants, Oxidation III - Dopant Redistribution, Oxidation IV - Oxide Charges

Diffusion I - Theory of Diffusion, Diffusion II - Infinite Source, Diffusion III - Actual Doping Profiles, Diffusion IV Diffusion Systems

Ion - Implantation Process, Ion - Implantation Process

Annealing of Damages

Masking during Implantation

Lithography – I, Lithography - II

Wet Chemical Etching, Dry Etching, Plasma Etching Systems, Etching of Si, Sio2, Sin and other materials, Plasma Deposition Process

Metallization – I, Problems in Aluminum Metal contacts

IC BJT - From junction isolation to LOCOS, Problems in LOCOS + Trench isolation

More about BJT Fabrication and Realization

Circuits + Transistors in ECL Circuits

MOSFET I - Metal gate vs. Self-aligned Poly-gate, MOSFET II Tailoring of Device Parameters

CMOS Technology, Latch - up in CMOS, BICMOS Technology

**Text Books:**

1. "Silicon VLSI Technology: Fundamentals, Practice and Modeling" by James D.Plummer, Michael D.Deal, Peter B.Griffin
2. "The Science and Engineering of Microelectronic Fabrication" by Stephen A. Campbell
3. "VLSI Technology" by C.Y. Chang and S.M.Sze

**Reference Books:**

1. " Digital Integrated Circuits" Demassa & Ciccone, Willey Pub.
2. "Modern VLSI Design: system on silicon" Wayne Wolf; Addison Wesley Longman Publisher
3. "Basic VLSI Design" Douglas A. Pucknell & Kamran Eshranghian; PHI
4. "CMOS Circuit Design, Layout & Simulation", R.J.Baker, H.W.Lee, D.E. Boyee, PHI

**Elective: Speech & Natural Language Processing**

Introduction – NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The problem of ambiguity. The role of machine learning. Brief history of the field.

N-gram Language Models – the role of language models. Simple N-gram models. Estimating parameters and smoothing. Evaluating language models.

Part of Speech Tagging and Sequence Labeling – Lexical syntax. Hidden Markov Models. Maximum Entropy Models. Conditional Random

Syntactic parsing – Grammar formalisms and treebanks. Efficient parsing for context-free grammars (CFGs). Statistical parsing and probabilistic CFGs (PCFGs). Lexicalized PCFGs.

Semantic Analysis – Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing.

Information Extraction (IE) – Named entity recognition and relation extraction. IE using sequence labeling.

Machine Translation (MT) – Basic issues in MT. Statistical translation, word alignment, phrase-based translation, and synchronous grammars.

**Reference Books:**

1. D. Jurafsky & J. H. Martin – "Speech and Language Processing – An introduction to Language processing, Computational Linguistics, and Speech Recognition", Pearson Education
2. Manning, Christopher and Heinrich Schütze. 1999. "Foundations of Statistical Natural Language Processing". MIT Press.
3. Allen, James. 1995. – "Natural Language Understanding". Benjamin/Cummings, 2ed.
4. Bharathi, A., Vineet Chaitanya and Rajeev Sangal. 1995. Natural Language Processing- "A Pananian Perspective". Prentice Hll India, Eastern Economy Edition.
5. Eugene Cherniak: "Statistical Language Learning", MIT Press, 1993.

**Elective: Theory of Programming Languages/Computing**

Concepts of structural program development; concept of data types; precedence and associatively of operators; conditional transfer; deterministic and in-deterministic loops; recursions; functions and procedures - call by value, call by reference and their differences; programming for numerical methods; records.
Data-type handling and various constructs (conditional, loop, functions etc); pointers: concept of pointers and passing parameters using pointers, non-numeric processing, concept of arrays of pointers and pointers to pointers; Structures and unions – advantage of using structures, concept of information hiding, pointers to structures; Files - basic concept of various types of file access methods: sequential, indexed sequential, random, various statements for file handling

Advanced Programming Languages like C++, ADA, LISP, PROLOG, and PASCAL. Comparison of various
languages

**Reference Books**:
1. Tennence W.Pratt, "Programming languages design and implementation", Prentice Hall of India.
2. Allen B. Tucker, "Programming Languages", Tata McGraw Hill.
3. Gottfried BS – Programming with C, TMH pub.
4. Balagurusamy: ANSI C TMH

**Elective: Cloud Computing**

Introduction to cloud computing – Overview of Computing, Cloud Computing NIST Model, Properties, characteristics and disadvantages, role of open standards.

Cloud computing architecture – cloud computing stack, service Models (XaaS), IaaS, Paas, SaaS, Daas, Deployment Models, private, public, hybrid, commercial cloud models.

Service management in Cloud computing – service level agreement (SLA), SLA violation, cloud economics.

Resource management in cloud computing – resource sharing, scalability, elasticity, transparency.

Data management in cloud computing – looking at data scalability and cloud services, database and data stores in cloud, large scale data processing

Cloud security – infrastructure security, data security and storage, identity and access management, access control, trust, reputation risk

Cloud simulators – CloudSim, CloudAnalyst, MultiRecCloudSim, CloudSimPlus, GreenCloudSimulator

Research trend in Cloud compting, green cloud computing, fog computing

**Reference Books:**

1. Cloud Computing: From Beginning to End, Ray J. Rafaels
2. Cloud Computing: A hands-on Approach, Arshdeep Bhaga and Vijay Madisetti
3. Cloud Computing: Concepts, Technology & Architecture and Cloud Computing Design Patterns, Thomas Erl and others
4. Cloudnomics: The Business Value of Cloud Computing
5. Amazon web Services for Dummies, Bernard Golden

**Elective: Authentication & Steganography**

Introduction to Biometrics: Introduction, Physiological or Behavioral, Verification vs. Identification, Applications, Biometrics Technologies, Working of Biometrics, Benefits, Application Design.

Fingerprint Recognition: What Is Fingerprint Scanning? Practical Applications for

Fingerprint Scanning, Accuracy and Integrity, Fingerprint Matching, Fingerprint Classification, Fingerprint Image Enhancement, Fingerprint Feature Extraction, Fingerprint Form Factors, Types of Scanners: Optical - Silicon – Ultrasound, Fingerprint Matching.

Speaker Recognition: Algorithms for training, recognition and adaptation to speaker and transmission channel, mainly based on Hidden Markov Models (HMM), methods for reducing the sensitivity to external noise and distortion, acoustic modeling of static and time-varying spectral properties of speech, statistic modeling of language in spontaneous speech and written text, specific analysis and decision techniques for speaker recognition.

Face Recognition: Introduction to Face Recognition, how is Face Recognition Technology Currently Being Used? How Well Does Face Recognition Work, Why Face Recognition, Face Recognition: How it Works, Image Quality, Facial Scan Process Flow, Verification vs. Identification, Primary Facial

Recognition Technologies, Facial Recognition Applications. Multi-Modal Biometrics: Introduction to Multi-Modal Biometric Systems, Fusion Methodology, Levels of Fusion, Feature-Extraction Level Fusion, Data-Matching Level Fusion, Probabilistic-Decision level Fusion, Fusion Procedure, Modes of Operation, Integration Strategies, Issues, Soft Biometrics, A Biometric Vision.

**Reference Books:**

1. Guide to Biometrics (Springer Professional Computing) by R. Bolle, J. Connell, S. Pankanti, N. Ratha, Springer Press, 2003, ISBN0387400893
2. Biometrics Personal Identification in Networked Society, Jain, Bolle, Pankanti 1999
3. Handbook of Fingerprint Recognition, Maltoni, Maio, Jain, Prabhakar, 2005
4. Biometric Systems, Wayman, Jain, Maltoni and Maio 2004
5. Fundamentals of Speech Recognition, L. Rabiner and B. Juang, , Pearson Education.
6. Speech and Audio Signal Processing, B. Gold and N. Morgan, John Wiley.
7. Spoken Language Processing, Huang, Acero & Hon, Prentice Hall, 2001.
8. Speech and Language Processing: An Intro to NLP, CL, and Speech Recognition (2nd Edition) Jurafsky & Martin, Prentice Hall, 2000.
9. Statistical Methods for Speech Recognition. Jelinek. MIT Press,
10. Fundamentals of Speech Recognition, Rabiner & Juang, Prentice-Hall,

**Elective: Computer Graphics**

Introduction: Video-Display Devices, Raster-Scan and Random-Scan Systems; Graphics Monitors, Input Devices, Points and Lines; Line Drawing Algorithms, Mid-Point Circle and Ellipse Algorithms; Scan Line Polygon Fill Algorithm, Boundary-Fill and Flood-Fill.

2-D Geometrical Transforms and Viewing: Translation, Scaling, Rotation, Reflection and Shear Transformations; Matrix Representations and Homogeneous Coordinates; Composite Transforms, Transformations Between Coordinate Systems, Viewing Pipeline, Viewing Coordinate Reference Frame, Window to View-Port Coordinate Transformation, Viewing Functions, Line and Polygon Clipping Algorithms.

3-D Object Representation: Geometric Transformations and Viewing: Polygon Surfaces, Quadric Surfaces, Spline Representation, Bezier and B-Spline Curves; Bezier and B-Spline Surfaces; Illumination Models, Polygon Rendering Methods, Viewing Pipeline and Coordinates; General Projection Transforms and Clipping.

**Reference Books:**

1. Hearn, Baker – “Computer Graphics (C version 2nd Ed.)” – Pearson education
2. Z. Xiang, R. Plastock – “Schaum’s outlines Computer Graphics (2nd Ed.)” – TMH
3. D. F. Rogers, J. A. Adams – “Mathematical Elements for Computer Graphics (2nd Ed.)” - TMH

**Elective: Digital Image Processing**

Introduction: Digital Image representation; Fundamental steps in Image processing, Elements of digital Image processing systems.
Digital Image Fundamentals: Sampling and quantization, imaging geometry.
Image Transforms: Fourier, Walsh, Hademord, discrete cosine and Hotelling transforms and their properties.
Image Enhancement: Enhancement by point processing, spatial filtering, Frequency domain enhancement, Color image processing.
Image Restoration: Unconstrained and constraint restoring, inverse filtering, Wiener Filter, Geometric transforms.
Image Compression: Image Compression models, Error-free compression, Lossy compression, Image compression standards.
Image Segmentation: Detection of discontinuities, edge linking, Thresholding.
Representations and Descriptions: Chain codes, shape numbers, moments and Fourier and other descriptors. Recognition & Interpretations.

**Text Book:**
1. Digital Image Processing, Gonzalves,Pearson
2. Digital Image Processing, Jahne, Springer India
3. Digital Image Processing &Analysis,Chanda&Majumder,PHI
4. Fundamentals of Digital Image Processing, Jain, PHI

**References Books:**
1. Image Processing, Analysis & Machine Vision, Sonka, VIKAS
2. Getting Started with GIS- Clarke Keith. C; PE.
3. Concepts & Techniques of GIS - Lo C.P, Albert, Yeung K.W- PHI.