# M. Tech. Computer Science and Engineering

## Two-Year Programme

### Academic Curriculum (2018 – 19 onwards)

#### First Year

<table>
<thead>
<tr>
<th>Autumn Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Contact Hours per Week</th>
<th>Credits</th>
<th>ETE Duration</th>
<th>Weightage (%)</th>
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<td>Hours</td>
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<td></td>
<td>CW</td>
<td>MTE</td>
</tr>
<tr>
<td>CS 521</td>
<td>Big Data Analytics</td>
<td>3 1 0 4</td>
<td>3</td>
<td>10</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>CS 511</td>
<td>Adhoc Sensor Networks</td>
<td>3 1 0 4</td>
<td>3</td>
<td>10</td>
<td>40</td>
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<tr>
<td>CS 515</td>
<td>Machine Learning</td>
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<tr>
<td>CS 523</td>
<td>Operations Research</td>
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<td>CS 521</td>
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<td>CS517</td>
<td>Adhoc Sensor Networks Lab</td>
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<thead>
<tr>
<th>Spring Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Contact Hours per Week</th>
<th>Credits</th>
<th>ETE Duration</th>
<th>Weightage (%)</th>
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<td>CS506</td>
<td>Distributed Operating Systems</td>
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<td>CS508</td>
<td>Soft computing Paradigms</td>
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<td>CS510</td>
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<td>CS512</td>
<td>Advances in Database Management Systems</td>
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<tr>
<td>Elective II</td>
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<td>CS516</td>
<td>Digital Image Processing &amp; Analysis lab</td>
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<td>HS501</td>
<td>Technical Communication*** (optional)</td>
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*** If a student opts for this optional course the corresponding credits will be added to her account.
List of Electives

**Elective I**
1. CS 563  Advances in Distributed Computing
2. CS 565  Advanced Compiler Construction
3. CS 567  BioInformatics
4. CS 569  Advanced Computer Graphics
5. CS 571  Advances in Algorithm Design

**Elective II**
1. CS 562  Mobile Cloud Computing
2. CS 564  Machine Intelligence & Robotics
3. CS 566  Natural Language Processing
4. CS 568  Advanced Software Engineering
5. CS 570  Mathematical Modelling
# M. Tech. Computer Science & Engineering

## Two-Year Programme

### Academic Curriculum (2017 – 18 onwards)

### Second Year

<table>
<thead>
<tr>
<th>Autumn Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Contact Hours per Week</th>
<th>Credits</th>
<th>ETE Duration</th>
<th>Weightage (%)</th>
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<tr>
<td></td>
<td>CS 601</td>
<td>Seminar</td>
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<td><strong>2 0 --</strong></td>
<td><strong>24</strong></td>
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### Spring Semester

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<tr>
<th>Spring Semester</th>
<th>Course Code</th>
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<th>Contact Hours per Week</th>
<th>Credits</th>
<th>ETE Duration</th>
<th>Weightage (%)</th>
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<tbody>
<tr>
<td></td>
<td>CS 606</td>
<td>Dissertation Final</td>
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<td></td>
<td><strong>0 0 --</strong></td>
<td><strong>20</strong></td>
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**Total Credits = 92**

* **Theory:** Assignments and regularity will be evaluated out of 10(ten) marks in a semester.

** Theory:** Two mid-term examinations of 20 (twenty) marks each.

*** The student may decide to take HS 501 in the even semester as an optional paper by consulting the course coordinator. If a student opts to take this paper, the appropriate credit shall be added to her account.
Objective(s):
- To learn Big Data characteristics
- To learn Hadoop architecture and functioning of Map-Reduce.
- To learn other Big data tools like HIVE, HIVEQL and HBASE.

Outcome(s):
The students will be able to carry out research in Big Data using the latest tools.

Text Books:

Reference Books:
Objective(s):
- To learn the Machine learning concepts.
- To learn different models of Machine learning.

1. **Foundations of Learning:** Components of learning, learning models, geometric models, probabilistic models, logic models, grouping and grading, learning versus design, supervised learning, unsupervised learning, reinforcement learning, theory of learning, feasibility of learning, error and noise, training versus testing, theory of generalization, generalization bound, approximation generalization trade off, bias and variance, learning curve.

2. **Linear Models:** Linear classification, univariate linear regression, multivariate linear regression, regularized regression, perceptron, multilayer neural networks, learning neural networks structures, support vector machines, soft margin SVM, going beyond linearity, generalization and overfitting, regularization, validation.

3. **Distance-based Models:** Nearest neighbor models, K-means clustering, hierarchical clustering, k-d trees, locality sensitive hashing, non-parametric regression, ensemble learning, bagging and random forests, boosting, meta learning.

4. **Tree and Rule Models:** Decision trees, learning decision trees, ranking and probability estimation trees, regression trees, clustering trees, learning ordered rule lists, learning unordered rule lists, descriptive rule learning, association rule mining, first-order rule learning.

5. **Reinforcement Learning:** Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal-difference learning, active reinforcement learning, exploration, learning an action utility function, generalization in reinforcement learning, policy search, applications in game playing, applications in robot control.

Outcome(s):
Students will be able to
- Compare and apply Machine learning models for different problems.
- Carry out research in the area of Machine learning.

Text Books:

Reference Books:
Objective(s): To learn major Operations research techniques.

1. **Introduction to Operation Research:** Origins of or, nature, impact and phases of OR, solving the OR model, operation research as tool for decision support system, productivity improvement, overview of OR research techniques.

2. **Deterministic OR Models:** Formulation of linear programming problem, linear programming models, assumptions of linear programming, graphical method of solving LP problem, Simplex method for solving LP problem, special cases in Simplex method application.

3. **Linear Programming Extensions:** Introduction and formulation of transportation problem, types of transpiration problems, methods of initial feasible solution, methods of optimum solution, unbalanced transportation problem, introduction to assignment problem, solution of an assignment problem, the transshipment model.

4. **Decision, Game & Queueing Theory:** Formulation of two person, zero-sum games, solving simple games, mixed strategies, non-zero sum games, basic structure & components of decision, decision criteria, decision trees, basic characteristics of queueing system, terminologies & notation, Poisson process of queueing, M/M/1 system queueing model. queueing decision models.

5. **Hybrid OR Models, Project Management PERT & CPM:** Assumption and comparison PERT & CPM, algorithms of PERT CPM techniques, fundamentals of network model, guidelines for network construction, critical path analysis, methods based on time estimates to find critical paths, concept of slack & oats in network analysis, Project Evaluation & Review Techniques (PERT).

6. **Dynamic Programming:** Terminologies, multi decision process, Bellman's principles of optimality, characteristics of dynamic programming problems, dynamic programming algorithms, solving LPP using dynamic programming, recent applications of dynamic programming in OR.

Outcome(s): Students will be able to apply Operation Research techniques relevant to their area of research.

Text Books:

Reference Books:
RM 17.101 Research Methodology Credit: 2-0-0-2

Prerequisite(s):

Objective(s):

1. **Introduction**: Meaning of research, Objectives, Motivation for Research, Types of Research, Research Approaches, Research Process, Validity and Reliability in Research.


4. **Data for research**: Types of Data, Sources of Data, Methods of Collecting Data, Data Presentation Techniques. Methods of Data Analysis.

5. **Data Analysis and Simulation Tool**: Introduction to SPSS, MATLAB, Network Simulators, ETAP, Solid Works, MultiSim.

6. **Report Writing**: Types of Reports, Contents, Style Manuals, Results & Findings, Contributions, Implications, Scope for future work and conclusion, Referencing Styles, Anti Plagiarism Policy.

Text Books:


Reference Books:

Objective(s): To learn the implementation of different Machine learning models.

Contents: Experiments based upon basic learning models, classification, generalization.
Experiments based upon linear models of learning.
Experiments based upon distance models.
Experiments based upon tree and rule models.
Experiments based upon reinforcement learning.

Outcome(s): Students will be able to apply and compare different Machine learning models.
Objective(s): To implement the Operations Research techniques.

Contents: Experiments based upon linear programming.
Experiments on Simplex method.
Experiments based upon Assignment problem and Transportation model.
Experiments based upon Game theory and Queuing theory.
Experiments based upon CPM/PERT.
Experiments based upon dynamic programming.

Outcome(s): Students will be able to implement and analyze different OR techniques.

2. **Pipeline Architecture**: Principles and implementation of Pipelining, Classification of pipelining processors, General pipelining reservation table, Design aspect of Arithmetic and Instruction pipelining, Pipelining hazards and resolving techniques, Data buffering techniques, Job sequencing and Collision, Advanced pipelining techniques, loop unrolling techniques, out of order execution, software scheduling, trace scheduling, Predicated execution, Speculative loading, Register Stack Engine, Software pipelining. [8]


4. **Multiprocessor Architecture**: Loosely and Tightly coupled multiprocessors, Processor characteristics of multiprocessors, Inter Processor communication network, Time shared bus, Crossbar switch, Multiport Memory Model, Memory contention and arbitration techniques, Cache coherency and bus snooping, Massively Parallel Processors (MPP), Processor, Inter Processor Communication and Synchronization. [8]


6. **Parallel Programming Techniques**: Message passing program development, Synchronous and asynchronous message passing, Message passing parallel programming, Shared Memory Programming, Data Parallel Programming. [6]

**Text Books:**

**Reference Book:**
1. **Ad hoc Networks**: Introduction and Definitions, Ad hoc Network Applications, Design Challenges. [3]


**Text Books:**

**Reference Book:**
1. Introduction: Elements of Information Security, Category of computer securities, types of attacks and services. [4]


3. Number Theory: Introduction to ring and field, prime and relative prime numbers, modular arithmetic, Fermat’s and Euler’s theorem, primality testing, Euclid’s Algorithm, Chinese Remainder theorem, discrete logarithms. [4]


Text Books:

Reference Books:
MA 531 Advanced Computational Mathematics 3-0-0-3

1. **Calculus of Finite Differences and Interpolation:** Finite differences and difference operators, Construction of difference tables, Interpolation and extrapolation with equal intervals (Newton- Gregory forward, backward, Stirling and Bessel’s formulas), Interpolation and extrapolation with unequal intervals (Newton’s divided difference and Lagrange’s formulas).

2. **Numerical Differentiation and Integration:** Numerical differentiation with equal and unequal intervals, numerical integration (newton-Cotes quadrature formula, Trapezoidal, Simpson’s 1/3, Simpson’s 3/8, Weddle’s and Romberg rules), Double and triple integration using Trapezoidal and Simpson’s rules.

3. **Numerical Solution of Simultaneous Equations:** Gauss elimination method (Partial Pivoting), Jacobie’s iteration method, Gauss Jordan method, Gauss Siedel iteration method.


6. **Linear Algebra:** Review of group, ring and field, Vector Spaces, Subspaces, Linearly dependent and independent, Basis, Dimensions, Isomorphism, Linear transformations and their matrix representations, Rank, Inverse of Matrices, Cauchy- Schwarz inequality, Eigenvalue, Eigenvectors.

**Text Books:**
3. Introduction to Linear Algebra with applications by Jim DeFranza and Daniel Gagliardi, TMH, Year 2013.

**Reference Books:**
2. Introduction Methods of Numerical Analysis by S.S. Shastry.
3. Applied Numerical methods with MATLAB by Steven C Chapra, TMH.
4. Introduction of Numerical Analysis by Forberg.
1. Basics of Network Simulation
2. Simulating a Local Area Network
3. Measuring Network Performance
4. Simulation of a Satellite Network
5. Simulating a Wi-Fi Network
6. Simulating a Wi-MAX Network
7. Simulating a Mobile Ad-hoc Network
8. Simulating a Wireless Sensor Network
9. Setting up a Bluetooth Network
10. Setting up a Zig-Bee Network
1. Implementation of Ciphers
   a) Play fair
   b) Hill cipher

2. Implementation of the concepts from number theory
   a) Fermat’s & Euler’s Theorem
   b) Primality testing
   c) Chinese Remainder Theorem

3. Implementation of Symmetric key algorithms like AES/DES

4. Implementation of Asymmetric key Algorithms like RSA/DSA.

5. Implementing hash code using MD5/SHA. And generate digital signature

Implement the following in C/C++/MATLAB:

1. Newton-Gregory’s formulae for forward and backward interpolation.
2. Stirling formula.
3. Bessel’s formula.
4. Newton’s divided difference formula.
5. Lagrange’s formula.
8. Trapezoidal rule.
11. Solution of differential equations by Euler’s method modified Euler’s method.
14. Bisection method
15. Regula Falsi method
17. Graeffe’s root squaring method.
18. Gauss elimination method (with partial pivoting).
19. Eigen values and eigen vectors.

2. **Distributed computing environment**: Design issues of distributed operating system- Transparency, Reliability, flexibility, Performance, scalability, heterogeneity, security. Distributed computing environment- Definition, components, and DCE cells. [5]


5. **Remote Method Invocation(RMI)**: Introduction, communication between distributed objects, design issues for RMI implementation of RMI, distributed garbage collection, time and global clock, clock synchronization, logical clock- Lamport time stamps, Vector time stamp, global state, event ordering, mutual exclusion, deadlock, election algorithms- Bully algorithm, Ring algorithm, distributed transactions. [5]

6. **Distributed shared memory**: Introduction, message passing vs DSM, implementation approaches to DSM, design and implementation issues- Structure and synchronization model. Granularity, Structure of shared memory space, consistency model, replacement strategy, thrashing. [6]

7. **Processes and Processors in Distributed Systems**: Threads, system models, processor allocation, scheduling fault tolerance. [4]

8. **Distributed File System**: Design, implementation, trends in distributed file system. [3]

**Text Books:**
Reference Book:
1. **Artificial Neural Networks:** Definition, benefits of Artificial Neural Networks, terminology, neuron models, activation function, network architectures, learning process, types of learning: Hebbian, competitive, error-correction, Boltzmann learning. [8]

2. **Types of Neural Networks:** Feed forward neural network: Single layer perceptron, limitations, multi layer perceptron, back propagation algorithm, practical considerations, radial basis function network. Recurrent networks: Hopfield network, NARX model, state space model, recurrent multi layer perceptron, second order networks. Self-organizing map, and principal component analysis. [12]

3. **Fuzzy Logic:** Basic concepts of fuzzy logic, crisp sets and fuzzy sets, operations and properties of crisp sets and fuzzy sets, crisp and fuzzy relations, fuzzy rules, fuzzification and defuzzification. [7]

4. **Fuzzy Logic Applications:** Pattern recognition, control engineering, image processing, neuro fuzzy application. [3]

5. **Genetic Algorithms:** Basic concepts, working principles, genetic operators, genetic programming, parsing trees and mathematical foundation of genetic algorithm. Other optimization methods: Swarm Intelligence, ant colony optimization. [6]

6. **Hybrid Systems:** Neuro genetic systems, fuzzy genetic systems and neuro fuzzy genetic systems, applications. [4]

**Text Books:**

**Reference Books:**


5. **Image Compression**: Information Content of an Image, Lossless and Lossy Compression Algorithms, Compression Standards.  

6. **Feature Extraction**: Representation, Topological Attributes, Geometric Attributes, spatial Moments, Texture, Boundary Based Description, Region Based Description, Intensity Based and Relational Description.  

7. **Recognition**: Deterministic Methods, Clustering, Neural Network, Template Matching, Statistical Classification, Syntactic Recognition, Tree Search, Graph Matching.  

**Text Books:**

**Reference Books:**
2. B. Chanda and D. Dutta Majumder ,” Digital Image Processing and Analysis”, PHI, 2002
1. **Object and Object-Relational Databases**: Introduction, Object relational features, Object database extensions to SQL, ODMG object model and the object definition language (ODL) [8]


4. **Database Recovery**: Recovery concepts, no-undo/redo recovery based on deferred update, recovery techniques based on immediate update, shadow paging, ARIES algorithm, recovery in multidatabase systems, database backup and recovery from catastrophic failures. [5]


6. **Distributed Databases**: Distributed Database concepts, types, distributed database architecture, fragmentation, distribution and allocation techniques, query processing and optimization in distributed databases, transaction management in distributed databases. [6]

**Text Books:**

**Reference Book:**
1. Study of UNIX commands with all their important options
2. Study system calls related to process & process control
3. Study system calls related to semaphore
4. Inter process communication using shared memory
5. Incrementing a counter in shared memory
6. Implement concurrent echo client-server application
7. Implement a distributed chat server using TCP sockets in java.
8. Simulation of Distributed mutual exclusion in java.
9. Write a program to implement RPC in “C”
10. Implement ‘Java RMI’ mechanism for accessing methods of remote systems.
11. Write a program to simulate the functionality of Lamport’s Logical clock in C.
12. Write a program to Implement Vector clock in C.
1. Overview of MATLAB environment, Programming, Data types, Structure, Arithmetic / Logical operations, Cell arrays, Script files, Functions. Implement following image processing concepts using MATLAB.
2. Fourier transform, discrete cosine transform, Walsh- Hadamard transforms and principal component analysis.
4. Smoothing, Mean filter, Ordered Statistic Filter, Sharpening, Low-pass, High-pass filters, Bandpass and Homomorphic Filtering.
5. Image Restoration using Inverse filtering, Minimum Mean-square Error Restoration.
8. Object representation, topological attributes, Extraction of object by Boundary based descriptors.
10. Object recognition problem with preprocessing, segmentation, feature extraction, and classification steps.

Reference Books:
1. Lab Exercises based on Developing objects, member functions and implementing Object oriented features in SQL
2. Lab Exercises based on Developing structured, semi-structured and unstructured data using XML. Developing programs based on XML Languages.
3. Lab Exercises based on Developing cost functions and optimizing SQL Queries
4. Lab Exercises based on developing strategies for physical database design and tuning in relational systems
5. Lab exercises based implementing horizontal fragmentation, vertical fragmentation, total replication and partial replication in distributed database systems.
1. **Process of Communication**: Clarity in pronunciation based on International Phonetic Alphabet and awareness of colloquial expressions. [7]

2. **Composition**: Letter Writing, resume writing, theme development, formats for introducing, instructing, persuading, referencing and summarizing. [7]

3. **Report Writing**: Types of reports and structure of formal reports. [4]

4. **Presentations**: Making presentations and participating in group discussions, importance of sequential presentations. [5]

5. **Miscellaneous**: Analyzing strategies and their correlation with writing patterns and editing information. [5]


4. **Asynchronous distributed computing:** Formal modeling of asynchronous systems using interacting state machines (I/O automata). Proving correctness of distributed algorithms. [6]


6. **Synchronizers.** Synchronizer applications. Synchronous vs. asynchronous distributed systems. [6]


9. **Locking:** Locking algorithms, optimistic algorithms, lock-free algorithms, lazy algorithms, Load scheduling and balancing techniques. [6]

**Text Books:**

**Reference Books:**
1. **Advanced Issues in Elementary topics**: Compiler, phases and passes, finite state machines, regular expressions and their applications to lexical analysis, implementation of lexical analyzer using LEX, CFG, bottom-up and top-down parsers, implementation of parsers using YACC. [10]

2. **Symbol Table Structure**: Storage classes, visibility and lifetime. Symbol attributes and symbol table entries, local symbol table management, and global symbol table structure, storage binding and symbolic registers. [6]


5. **Register Allocation**: Register allocation and assignment, local methods, graph coloring, priority based graph coloring. Code Scheduling: Instruction Scheduling, Speculative loads and boosting, speculative scheduling, trace scheduling, percolation scheduling. [8]

6. **Interprocedural Analysis and Optimization**: Call graph, interprocedural data flow analysis, constant propagation, alias analysis, optimizations and register allocation. [7]

7. **Automatic Code Generators**: Syntax directed technique, semantic directed parsing, tree pattern matching and dynamic programming. [5]

**Text Books:**

**Reference Books:**
1. **Introduction to Bioinformatics**: Definition and History of Bioinformatics, Internet and Bioinformatics, Introduction to Data Mining, Applications of Data Mining to Bioinformatics Problems and Applications of Bioinformatics. [6]

2. **Bioinformatics Databases**: Introduction, Nucleotide sequence database - Protein sequence databases, Sequence motif databases, Protein structure databases, other relevant databases. [6]

3. **Data storage and retrieval and Interoperability**: Flat files, relational, object oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt), Introduction to Metadata and search; Indices, Boolean, Fuzzy, Neighboring search. The challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts. General Introduction to XML, UMLS, CORBA, PYTHON. [13]

4. **Sequence Alignments and Visualization**: Introduction to Sequences, alignments and Dynamic Programming: Local alignment and Global alignment (algorithm and example), Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal W algorithm). Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization. [12]


6. **Semantic Web Techniques**: Bridging databases, browsing space of information, life sciences identifiers, RDF data representation. [5]

7. **Bioinformatics and Distributed Computing**: Java Distributed computing platform, DPRml, DSEARCH. [5]

**Text Books**

**Reference Books**
1. **Animation:** Introduction of computer Animation, Principles of Animation, Keyframing, Kino-dynamics Planning - motion blending, skinning-skeleton animation, rigid skinning, linear skinning, dual skinning, physics modeling-Physics-based animation, rigid body systems, articulated rigid bodies, forward and inverse dynamics. [14]

2. **Rendering:** Basic concepts of graphics models-illumination & reflection models, Shading-Scanning polygons, Gourad and Phong shading, texture mapping, bump & environmental maps, mipmaps, shading languages-vertex shaders and fragment shaders. [12]

3. **Modeling:** Representation, Using homogeneous Coordinate systems, Modeling process, terrain-representation, methods, fault formation & weather, plants modeling, animals modeling. [12]

4. **Surface Representation:** 3 dimensional object representation - polygon representations, implicit representation, Beziers, B-splines-basis function, knot insertion, conversion, rational B-splines (NURBS)-properties and examples, evaluators, subdivision surfaces-coarse mesh and subdivision rule, types of subdivisions, Voxels. [14]

**Text Books:**

**Reference Books:**
1. **Pattern matching algorithms**: Finite automata and regular expression, recognition of regular expression patterns, recognition of substrings, Two – way deterministic pushdown automata, position trees and substring identifiers.

2. **Computability theory**: Turing machines, variants of Turing machines, Hilbert’s problem, decidable languages, the halting problem, Un-decidable problems from language theory, mapping reducibility, the recursion theorem, decidability of logical theories, Turing reducibility, definition of information.

3. **Fast Fourier Transform and Polynomials**: Representation of polynomials, the DFT and FFT algorithms, efficient FFT implementation, the FFT using bit operations, products of polynomials, the Schonhage – Strassen integer multiplication algorithm.


5. **Complexity theory**: Time complexity, the classes P, NP, NP complete and NP hard, Hierarchy theorems, Relativization, Circuit Complexity, approximation algorithms, probabilistic algorithms, circuit complexity, alteration, interactive proof systems, parallel computation, cryptography.

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**Text Book:**


**Reference Books:**

1. **Introduction:** Cloud, Business and IT Perspective, Virtualization, Cloud Services Requirements, Cloud And Dynamic Infrastructure, Cloud Computing Characteristics, Cloud Adoption. [8]


4. **Cloud Solutions:** Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management, Cloud Stack, Computing On Demand, Cloud Sourcing. [8]

5. **Cloud Offerings:** Virtual Desktop Infrastructure, Storage Cloud. [5]


**Text Books:**

**Reference Books:**
1. **Introduction:** Importance of AI, Knowledge Based System, Knowledge organization & manipulation, Conceptual Introduction to LISP and other AI programming Languages. [10]


3. **Knowledge Organization & Manipulation:** Search & control strategies, matching techniques, knowledge organization & management, Genetic Algorithms based search techniques. [10]

4. **Robotics:** Types of Robots, spatial transformation and kinematics of open chain linkages. Mobile robots, Actuators, sensors, programming and control. Applications - motion planning, grasping and industrial automation. [12]


**Text Books:**

**Reference Books:**


6. **NLP with Python:** Introduction, Processing Raw Text, Writing Structured Program, Categorizing and Tagging words, learning to Classify Text, Analyzing Sentence Structure. [8]

**Text Book:**

**Reference Books:**
1. **Introduction:** Software life cycle models, Waterfall, Prototype, Evolutionary and Spiral Models, Overview of Quality Standards like ISO 9001, SEI – CMM, Software Requirements analysis & specifications, Software Project Management. [8]

2. **Fundamental issues in software design:** Goodness of design, cohesions, coupling, Classification of Cohesiveness & Coupling, Function-oriented design: structured analysis and design. [8]

3. **Software Testing:** Testing process, Design of test cases, functional testing: Boundary value analysis, Equivalence class testing, Decision table testing, Cause effect graphing, Structural testing, Path Testing, Data flow and mutation testing, Unit Testing, Integration and System Testing, Debugging, Alpha & Beta Testing, Regression Testing, Testing Tools & Standards. [10]

4. **Object Oriented System Analysis and Design:** Object oriented and object basics, object oriented system development cycle, process framework of OOSAD, unified approach UML, UML Diagrams: class diagram, use-case diagram, behavior diagram, OOAP, OOD and OODBMS. [8]


**Text Books:**

**Reference Books:**
1. **Introduction**: Basics of modeling, mathematical models, Modeling change with difference equations, Approximate change with difference equations, solutions to dynamical systems, systems of difference equations. Modeling using proportionality, modeling using geometric similarity. [12]

2. **Model fitting and Experimental modeling**: Fitting models to data graphically, analytic method of model fitting, applying the least square criterion, choosing a best model, one term models, high order polynomial models, smoothing of low order polynomial models, cubic spline models. [10]

3. **Simulation modeling**: Introduction, simulating deterministic behavior: area under a curve, generating random numbers, simulating probabilistic behavior, queuing models. Introduction to some simulators. [10]

4. **Discrete modeling**: Probability modeling with discrete systems, linear regression, an overview of discrete optimization modeling, linear programming: geometric and algebraic solutions, simplex method. [10]


**Text Books:**


**Reference Books:**