# Information Technology, Computer Science and AI

| Unit | Unit Description                       |
|------|--|
| 1    | Engineering Mathematics                |
| 2    | Digital Logic                          |
| 3    | Computer Organization and Architecture |
| 4    | Algorithms                             |
| 5    | Programming and Data Structures        |
| 6    | Theory of Computation                  |
| 7    | Compiler Design                        |
| 8    | Theory of Computation and Compilers    |
| 9    | Operating System                       |
| 10   | Computer Networks                      |
| 11   | Cyber Security                         |
| 12   | Data Science                           |
| 13   | Artificial Intelligence (AI)           |
| 14   | Web Programming & Computer Graphics    |

## **Unit 1: Engineering Mathematics**

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability and Statistics: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional

probability and Bayes theorem.

## **Unit 2: Digital Logic**

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations (binary, decimal, octal and hexadecimal) and computer arithmetic (fixed and floating point).

#### **Unit 3: Computer Organization and Architecture**

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

#### **Unit 4: Algorithms**

Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph traversals, minimum spanning trees, shortest paths

#### **Unit 5: Programming and Data Structures**

Programming in Python. Collections - tuples, lists, strings and dictionary; builtin modules - math, statistics, random; user defined functions with mutable and immutable parameters; scope of variables; Recursion; implementation of stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs using python collections.

#### **Unit 6: Theory of Computation**

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability.

#### **Unit 7: Compiler Design**

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination.

#### **Unit 8: Operating System**

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems.

## **Unit 9: Databases**

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

#### **Unit 10: Computer Networks**

Concept of layering: OSI and TCP/IP Protocol Stacks; Basics of packet, circuit and virtual circuit-switching; Data link layer: framing, error detection, Medium Access Control, Ethernet bridging; Routing protocols: shortest path, flooding, distance vector and link state routing; Fragmentation and IP addressing, IPv4, CIDR notation, Basics of IP support protocols (ARP, DHCP, ICMP), Network Address Translation (NAT); Transport

layer: flow control and congestion control, UDP, TCP, sockets; Application layer protocols: DNS, SMTP, HTTP, FTP, Email.

#### Unit 11: Data Science

Introduction: Introduction to Data Science, Exploratory Data Analysis and Data Science Process. Motivation for using Python for Data Analysis, Introduction of Python shell iPython and Jupyter Notebook.

Essential Python Libraries: NumPy, pandas, matplotlib, SciPy, scikit-learn, statsmodels

Getting Started with Pandas: Arrays and vectorized computation, Introduction to pandas Data Structures, Essential Functionality, Summarizing and Computing Descriptive Statistics. Data Loading, Storage and File Formats.

Reading and Writing Data in Text Format, Web Scraping, Binary Data Formats, Interacting with Web APIs, Interacting with Databases

Data Cleaning and Preparation.

Handling Missing Data, Data Transformation, String Manipulation

Data Wrangling: Hierarchical Indexing, Combining and Merging Data Sets Reshaping and Pivoting.

Data Visualization matplotlib: Basics of matplotlib, plotting with pandas and seaborn, other python visualization tools

Data Aggregation and Group operations: Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation

Time Series Data Analysis: Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion, Moving Window Functions.

Advanced Pandas: Categorical Data, Advanced GroupBy Use, Techniques for Method Chaining

#### **Unit 12: Artificial Intelligence**

Approaches to AI: Turing Test and Rational Agent Approaches; State Space Representation of Problems, Heuristic Search Techniques, Game Playing, Min-Max Search, Alpha Beta Cutoff Procedures.

Knowledge Representation: Logic, Semantic Networks, Frames, Rules, Scripts, Conceptual Dependency and Ontologies; Expert Systems, Handling Uncertainty in Knowledge.

Planning: Components of a Planning System, Linear and Non Linear Planning; Goal Stack Planning, Hierarchical Planning, STRIPS, Partial Order Planning.

Natural Language Processing: Grammar and Language; Parsing Techniques, Semantic

Analysis and Pragmatics.

Multi Agent Systems: Agents and Objects; Agents and Expert Systems; Generic Structure of Multiagent System, Semantic Web, Agent Communication, Knowledge Sharing using Ontologies, Agent Development Tools.

Fuzzy Sets: Notion of Fuzziness, Membership Functions, Fuzzification and Defuzzification; Operations on Fuzzy Sets, Fuzzy Functions and Linguistic Variables; Fuzzy Relations, Fuzzy Rules and Fuzzy Inference; Fuzzy Control System and Fuzzy Rule Based Systems.

Genetic Algorithms (GA): Encoding Strategies, Genetic Operators, Fitness Functions and GA Cycle; Problem Solving using GA.

Artificial Neural Networks (ANN): Supervised, Unsupervised and Reinforcement Learning; Single Perceptron, Multi Layer Perceptron, Self Organizing Maps, Hopfield Network.

## Unit 13: Cyber Security

Computer & Network security concepts. Network Security: Malwares, Cryptography and Steganography; Fundamentals of cryptography and its application to network security, Cybersecurity infrastructure policy or technical security policy for an organization, Cybersecurity infrastructure components, common vulnerabilities in networks, Secret-Key Algorithms, Public-Key Algorithms, Digital Signature, Virtual Private Networks, Firewalls.

Threat modeling, OWASP, fuzzing, clickjacking

## Unit 14: Web Programming and Computer Graphics

Introduction to hypertext markup language (html) document, creating web pages, graphical elements, lists, hyperlinks, tables, web forms, inserting images, frames. Customized Features: Cascading style sheets, (css) for text formatting and other manipulations.

JavaScript: Data types, operators, functions, control structures, events and event handling.

JDBC: JDBC Fundamentals, Establishing Connectivity and working with connection interface, Working with statements, Creating and Executing SQL Statements, Working with Resultset Objects.