

Data Structures

Module 1: Introduction to Data Structures

- What are data structures?
- Types of data structures:
 - Primitive vs Non-Primitive
 - Linear vs Non-Linear
- Abstract Data Types (ADTs)
- Time and space complexity basics (Big O notation)
- Algorithm analysis fundamentals

Module 2: Arrays and Strings

- One-dimensional and multidimensional arrays
- Operations: traversal, insertion, deletion, search, update
- Dynamic arrays (ArrayList, Vector)
- Applications of arrays
- Strings and string operations
- Character arrays vs string objects
- Common string algorithms:
 - Reverse, Palindrome, Anagram
 - Pattern Matching (Naive, KMP)

Module 3: Linked Lists

- Singly linked list
- Doubly linked list
- Circular linked list
- Operations: insertion, deletion, traversal, search
- Reverse a linked list
- Detect and remove loop (Floyd's Cycle Detection)
- Applications and memory efficiency

Module 4: Stacks

- Stack ADT and use cases
- Array and Linked List implementation
- Operations: push, pop, peek, isEmpty
- Infix, prefix, and postfix expression conversion
- Expression evaluation using stacks
- Balanced parentheses checking
- Undo functionality and recursion stack

Module 5: Queues

- Queue ADT and applications
- Types:
 - Simple queue

- Circular queue
- Deque (double-ended queue)
- Priority queue
- Array and Linked List implementations
- Queue operations (enqueue, dequeue, etc.)
- Use in scheduling and resource management

Module 6: Trees

- Binary trees:
 - Terminologies (node, level, height, etc.)
 - Representation (linked, array)
 - Traversals (inorder, preorder, postorder, level-order)
- Binary Search Trees (BST)
 - Insertion, deletion, search
- Balanced trees:
 - AVL Tree
 - Red-Black Tree (intro)
- Heaps (Min-Heap, Max-Heap)
- Trie (Prefix tree) – basic intro
- Applications: Huffman coding, decision trees

Module 7: Recursion and Backtracking

- Basics of recursion
- Recursive vs iterative approach
- Tail and non-tail recursion
- Applications:
 - Factorial, Fibonacci
 - Tower of Hanoi
 - N-Queens problem
 - Maze solving

Module 8: Hashing

- Hash tables and hash functions
- Collision resolution techniques:
 - Chaining
 - Open addressing (linear, quadratic, double hashing)
- Load factor
- Applications:
 - Dictionary/map
 - Caching
 - Frequency counting

Module 9: Graphs

- Graph terminology: vertices, edges, adjacency
- Representations:
 - Adjacency matrix

- Adjacency list
- Types of graphs: Directed, Undirected, Weighted, Unweighted
- Traversal algorithms:
 - BFS (Breadth-First Search)
 - DFS (Depth-First Search)
- Applications:
 - Topological sort
 - Connected components
 - Shortest path algorithms (Dijkstra's, Bellman-Ford)
 - Minimum spanning tree (Prim's, Kruskal's)

Module 10: Searching and Sorting Algorithms

- Linear Search, Binary Search
- Sorting Algorithms:
 - Bubble Sort
 - Insertion Sort
 - Selection Sort
 - Merge Sort
 - Quick Sort
 - Heap Sort
 - Counting Sort, Radix Sort (intro)
- Time and space complexity of all algorithms
- Stability and in-place characteristics

Module 11: Advanced Data Structures (Optional)

- Segment Trees
- Fenwick Tree (Binary Indexed Tree)
- Disjoint Set (Union-Find)
- Suffix Trees and Arrays
- K-D Tree (intro)

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