



# DATA STRUCTURES & ALGORITHMS - COURSE CONTENTS

This document describes the course contents of  
Data Structures & Algorithms





## Table of Contents

Week 01 – Introduction to Data Structures & Back to Arrays .....	2
Week 02 – Back to Functions - Time & Space Complexity .....	5
Week 03 – A Tour to Structures & Pointers .....	7
Week 04 – Searching & Sorting.....	9
Week 05 – Linked Lists & Applications.....	10
Week 06 – Stacks & Applications.....	11
Week 07 – Queues & Applications.....	12
Week 08 – Trees & Applications .....	13
Week 09 – Greedy Algorithms & Applications.....	15
Week 10 – Divide & Conquer Algorithms – Applications.....	16
Week 11 – Graphs & Applications .....	17
Week 12 – Hashing & Applications .....	18
Week 13 – Dynamic Programming.....	19



## **DATA STRUCTURES & ALGORITHMS**

### **COURSE CONTENTS**

#### **Week 01 – Introduction to Data Structures & Back to Arrays**

**Introduction to Data Structures**

**Applications of Data Structures**

**Types of Data Structures**

- A. Physical vs Logical Data Structures**
- B. Linear vs Non-linear Data Structures**

**Introduction to Arrays**

**Need for Arrays**

**1-D Arrays**

**Define and Initialize**

**Memory Map of 1-DArray**

**Traversing through the elements**

**Copy operation**

**Sum & Average of elements**

**Min & Max of the elements**

**Insert elements at given index**

**Insert elements before/after given element**

**Finding the Frequency of elements**

**Shift & Rotate operations**



## Data Structures & Algorithms

### Course Content

#### 1-D Arrays

Reversing the elements - efficient way

Finding Duplicate elements in unsorted Array

Sorting elements

- A. Selection Sort and
- B. Bubble Sort

Searching for elements – Linear Search

Finding Duplicate elements in sorted Array

Delete duplicate elements

Merging of elements from two arrays into one array

Set operations on Arrays

- A. Union
- B. Intersection and
- C. Difference

#### 2-D Arrays

Define and Initialize

Memory Map of 2-DArray

Traversing through the elements

- A. Row by Row
- B. Column by Column

Copy operation

Sum & Average of elements

- A. Row by Row
- B. Column by Column



## Data Structures & Algorithms

### Course Content

#### 2-D Arrays

##### Min & Max of the elements

- A. Row by Row
- B. Column by Column

##### Row-major and Column major representation

##### Operations on Matrices

- A. Addition
- B. Subtraction
- C. Multiplication and
- D. Transpose

##### Operations on Diagonal elements

##### Operations on Upper/Lower Triangle elements

##### Operations on Symmetric Matrices

##### Tri-diagonal and Tri-band matrices

##### Toeplitz Matrix

##### Sparse Matrix representation

##### Operations on Sparse Matrices

- A. Addition
- B. Subtraction
- C. Multiplication and
- D. Transpose

##### Polynomial Representation using Arrays

##### Operations on Polynomials

- A. Addition
- B. Subtraction and
- C. Multiplication



## **Week 02 – Back to Functions - Time & Space Complexity**

**Basics of Functions**

**Scope Rules and Blocks**

**Calling and Called Functions**

**Prototyping and its necessity**

**Functions Returning Non-integers**

**Passing basic data type arguments**

**Call by Value - Limitations**

**Introduction to Call by Reference**

**Advantages of Call by Reference**

**Storage Classes - Classification**

**External Variables**

**Introduction to Recursion**

**How recursion works**

**Role of Stack in Recursion**

**Generalizing Recursion**

**Building the base conditions**

**Types of Recursion**

**i) Direct Recursion**

- A. Tail Recursion**
- B. Head Recursion**
- C. Tree Recursion**
- D. Nested Recursion**

**ii) Indirect Recursion**



## Data Structures & Algorithms *Course Content*

**Passing 1-D and Multi-dimensional Arrays as arguments**

**Applying Recursion**

- A. Printing natural numbers up to N**
- B. Sum of first N natural numbers**
- C. Factorial of a given number**
- D. Sum of digits**
- E. Fibonacci Series**
- F. Taylor Series**
- G. Horner's Rule**
- H. Towers of Hanoi**

**Recursion vs Iteration**

**Introduction to Time and Space Complexity**

- A. Best case**
- B. Worst case and**
- C. Average Case**

**Measuring the Time & Space Complexity of given code snippets**

**Finding the Nth term of Fibonacci Series – Improved version**

**Role of Static & Global variables in Recursion**

**Deriving and Solving Recurrence Relations**

**Master's Theorem**



## Week 03 – A Tour to Structures & Pointers

Need for Structures

Structures – Terminology

Defining Structures and Structure variables

Implementing Structures

Operations on Structures

Copying Structure elements

Nested Structures

Using Bitfields in Structures

Passing Structures to Function – Call by Value

Applications of Structures

Limitations of fixed size arrays

Introduction to Dynamic Memory Allocation (DMA)

Stack vs Heap memory

Pointers & DMA

Implementing DMA functions

- malloc()
- calloc()
- realloc()
- free()





## Data Structures & Algorithms *Course Content*

**Pointers to Structures**

**DMA - 1D Arrays**

**DMA - 2D Arrays**

**DMA – Structures**

**DMA – Array of Structures**

**DMA - Nested Structures**

**Passing Structure variables to Functions – Call by Value**

**Passing Structure variables to Functions – Call by Reference**

**Returning Structure variables from Functions – By Value**

**Returning Structure variables from Functions – By Reference**

**Introduction to Self-referential structures**

**Applications of Self-referential structures**



## **Week 04 – Searching & Sorting**

**Need for Searching & Sorting**

**Concept and Implementation of Linear Search**

**Concept and Implementation of Binary Search**

**Finding missing element using Binary Search**

**Find duplicate elements in sorted Array – Improved version**

**Selection Sort and its applications**

**Bubble Sort and its applications**

**Recursive Bubble Sort**

**Insertion Sort and its applications**

**Recursive Insertion Sort**

**Quick Sort and its applications**

**Recursive Quick Sort**

**Counting Sort and its applications**

**Shell Sort and its applications**

**Merge Sort and its applications**

**Recursive Merge Sort**

**Radix Sort and its applications**

**Pigeonhole Sort**

**Time & Space Complexity Analysis of Searching & Sorting techniques**



## Week 05 – Linked Lists & Applications

Self-referential Structures in play

Linked Lists – Introduction & Terminology

Types of Linked Lists

- A. Single Linked List
- B. Circular Single Linked List
- C. Double Linked List
- D. Circular Double Linked List

Representation of Linked Lists

Operations on Linked Lists

- A. CRUD operations
- B. Merging of Linked Lists
- C. Reversing Linked Lists
- D. Ordered Linked Lists
- E. Finding Duplicates in Linked Lists
- F. Finding no. of nodes in linked list - efficient way
- G. Finding Cycles in linked lists

Sparse Matrix representation

Operations on Sparse Matrices

Polynomial Representation using Linked List

Operations on Polynomials



## Week 06 – Stacks & Applications

Concept of Stack

Examples of Stack

Preliminary operations on Stack

Stack implementation

- A. Using Array
- B. Using Linked List

Implementation of two Stacks in Array

Applications of Stack

Reversing a String

Parenthesis matching problem

Introduction to Infix, Postfix and Prefix expressions

Conversion programs

- A. Infix to Postfix
- B. Infix to Prefix
- C. Postfix to Infix
- D. Postfix to Prefix
- E. Prefix to Infix
- F. Prefix to Postfix

Evaluation of Infix, Postfix and Prefix expressions

Validating the correctness of XML file content



## Week 07 – Queues & Applications

Concept of Queue

Examples of Queue

Preliminary operations on Queue

Queue implementation

- A. Using Array
- B. Using Linked List

Types of Queues & Implementations

- A. Linear Queue – Pros & Cons
- B. Circular Queues – Pros & Cons
- C. Double-ended Queues – Pros & Cons
- D. Priority Queues
  - 1. Sorted & Unsorted Arrays
  - 2. Sorted & Unsorted Linked Lists

Implementing Queue using Stacks

Applications of Queues

- A. Simulation of Teller machine
- B. Simulation of Doctor Appointment system
- C. Calculation of Wait time in a Queue
- D. Check if a Queue can be sorted into another Queue - using Stack
- E. Reversing Queue using Recursion
- F. Sorting Queue with no extra space



## Week 08 – Trees & Applications

Concept of Trees

Examples of Trees

Terminology

Types of Trees

Preliminary operations on Trees

Binary Trees & Properties

Implementation of Binary Tree

- A. Arrays
- B. Linked List

Binary Tree Traversal techniques

Operations on Binary Trees

Binary Search Tree & Properties

Implementation of Binary Search Tree

Operations on Binary Search Trees

Deletion from BST - All cases

Applications of BST

Expression Trees & Properties

Representation of Expression Trees



**Data Structures & Algorithms**  
*Course Content*

**Concept of Heap**

**Implementation of Heap**

**Operations on Heap**

**Applications of Heap**

**Implementation of Expression Trees**

**Need for Balancing the Height of the Tree**

**AVL Trees & Properties**

**Rotations in AVL Trees**

**Implementation of AVL Trees**

**Operations on AVL Trees**

**Applications of BST**

**2-3 Trees**

**Operations on 2-3 Trees**

**Implementation of 2-3 Trees**

**2-3-4 Trees**

**Operations of 2-3-4 Trees**

**Implementation of 2-3-4 Trees**

**Red-Black Trees**

**Operations on Red-Black Trees**



## Week 09 – Greedy Algorithms & Applications

Concept of Greedy algorithms


Nature of Greedy Algorithms

Examples of Greedy Algorithms

Pros & Cons of Greedy Algorithms

Implementation of Greedy Algorithms

Applications of Greedy Algorithms

- 
- A. Coin Change
  - B. Rod Cutting
  - C. Minimum Product Subset
  - D. Maximum Array Sum
  - E. Job sequencing
  - F. Activity Selection
  - G. No. of Railway Platforms
  - H. Huffman Encoding
  - I. Water Connection
  - J. Minimum Swaps for Bracket Balancing
  - K. Fractional Knapsack





## Week 10 – Divide & Conquer Algorithms – Applications

Concept of D & C algorithms

Nature of D & C Algorithms

Examples of D & C Algorithms

Quick Sort – Revisited

Merge Sort - Revisited

Pros & Cons of D & C Algorithms

Implementation of D & C Algorithms

Applications of D & C Algorithms

- A. Finding the Power
- B. Inversion Count
- C. Count of 0s
- D. Missing element in Arithmetic Series
- E. Polynomial Multiplication
- F. Karatsuba's Fast Multiplication Algorithm
- G. Strassen's Fast Matrix Multiplication Algorithm
- H. The Tiling Problem



## **Week 11 – Graphs & Applications**

**Concept of Graph**

**Terminology**

**Differences between Tree and Graph**

**Examples of Graph**

**Types of Graphs**

**Representation of Graph**

- A. Adjacency Matrices**
- B. Adjacency List**
- C. Adjacency Multi list**

**Preliminary operations on Graph**

**Implementation of Graph**

**Graph Traversing techniques**

- A. Breadth First Search**
- B. Depth First Search**

**Spanning Trees**

**Spanning Tree vs Graph**

**No. of possible Spanning Trees – Kirchhoff's Theorem**

**Minimum Cost Spanning Trees**

**Implementation of Prim's Algorithm**

**Implementation of Kruskal's Algorithm**

**Implementation of Warshall's algorithm**

**Implementation of Topological Sorting**

**Applications of Graphs**



## Week 12 – Hashing & Applications

Concept of Hashing

Need for Hashing

Examples of Hashing

Common Hashing functions

Address calculation techniques in Hashing

Collision and Resolution in Hashing

Implementation of Hashing

- A. Chaining
- B. Linear Probing
- C. Quadratic Probing
- D. Double Hashing

Load Factor and Rehashing

Applications of Hashing

- A. Highest Frequency element in an array
- B. Finding if an array is subset of another array
- C. Union and Intersection of two linked lists
- D. Minimum delete operations in an array to make all the elements same
- E. Check if two given sets are disjoint



## Week 13 – Dynamic Programming

Concept of Dynamic Programming

Nature of Dynamic Programming Problems

Pros & Cons of Dynamic Programming

Optimal vs Sub-optimal Solution

Introduction to Memoization – Nth Fibonacci Term

Property of Overlapping Subproblem

Tabulation vs Memoization

Applications of Dynamic Programming

- A. Coin Change
- B. Rod Cutting
- C. Tiling
- D. Gold Mine
- E. Friend Pairing
- F. Subset Sum
- G. Largest Divisible Pairs
- H. Longest Common Sub-sequence
- I. Shortest Common Super-sequence
- J. Knapsack

**What next ???**