

**Unit - I****Chapter 1 : Introduction to Algorithms****1-1 to 1-14**

1.1	Introduction to Algorithms.....	1-1
1.1.1	Definition and Characteristics	1-1
1.1.2	Algorithm Design Tools	1-3
1.1.2(A)	Flowcharting	1-3
1.1.2(B)	Pseudo-Language	1-3
1.1.3	Relation between Data Structure and Algorithm	1-5
1.2	Program Development.....	1-5
1.3	Algorithm Analysis (Using Step Count).....	1-6
1.3.1	Measuring the Running Time of a Program (Time Complexity)	1-8
1.3.2	Measurement of Growth Rate (Asymptotic Growth Rate)	1-8
1.3.2(A)	Asymptotic Consideration.....	1-8
1.3.2(B)	Constant Factor in Complexity Measure	1-9
1.3.3	Notation O : (Pronounced as Big-Oh), ($O(n^2)$) is Pronounced as Big-Oh of n^2)	1-9
1.3.4	Best Case, Worst Case and the Average Case Behaviour.....	1-11
1.3.5	Different Algorithm Asymptotic Notation	1-12
1.3.5(A)	The Notation O (Big-Oh).....	1-12
1.3.5(B)	The Notation Ω (Omega).....	1-12
1.3.5(C)	The Notation Θ (Theta).....	1-13
1.3.6	Graphical Interpretation of Different Notations.....	1-13
1.4	Programming Constructs-linear, Quadratic, Cubic and Logarithmic.....	1-13
1.4.1	Constant-Time Algorithms [$O(1)$].....	1-13
1.4.2	Linear-Time Algorithm [$O(n)$]	1-14

1.4.3	Quadratic-Time Algorithm [$O(n^2)$].....	1-14
1.4.4	Cubic-Time Algorithm [$O(n^3)$].....	1-14
1.4.5	Logarithmic-Time Algorithm [$\log(n)$].....	1-14

Chapter 2 : Data Structures and Algorithmic Strategies**2-1 to 2-16**

2.1	Data	2-1
2.1.1	Data Types.....	2-1
2.1.2	Abstract Data Types (ADT)	2-1
2.1.3	Data Object	2-3
2.2	Data Structures	2-3
2.2.1	Types/Classification of Data Structures	2-4
2.2.1(A)	Primitive and Non-Primitive	2-4
2.2.1(B)	Linear and Non-Linear	2-4
2.2.1(C)	Static and Dynamic	2-5
2.2.1(D)	Persistent and Ephemeral	2-6
2.2.1(E)	Relationship among Data Object, Data Type, Data Structure and Data Representation	2-6
2.3	Algorithmic Strategy	2-7
2.4	Divide and Conquer.....	2-7
2.4.1	Binary Search.....	2-7
2.4.2	Examples of Divide and Conquer Strategy	2-8
2.4.2(A)	'Divide and Conquer' Strategy for Tower of Hanoi	2-8
2.4.2(B)	Merge Sort	2-8
2.4.2(C)	Quick Sort	2-9
2.4.2(D)	Finding of Maxima	2-9
2.5	The Greedy Method.....	2-9
2.5.1	Job Sequencing with Deadlines.....	2-11
2.5.2	Graph Colouring Problem	2-11
2.6	Generating Functions	2-12
2.7	Multiplication Technique	2-16

**Unit - II****Chapter 3 : Linear Data Structures****using Sequential Organization 3-1 to 3-54**

3.1	Sequential Organization	3-1
3.2	Introduction to Arrays	3-2
3.3	Representation and Analysis	3-2
3.4	One-Dimensional Arrays	3-3
3.5	Operations with Arrays	3-4
3.5.1	Deletion	3-4
3.5.2	Insertion	3-5
3.5.3	Search.....	3-6
3.5.4	Merging of Sorted Arrays.....	3-7
3.5.5	Reversing an Array.....	3-9
3.6	Two-Dimensional Arrays.....	3-9
3.6.1	Initializing Two-Dimensional Arrays	3-10
3.6.2	Address Calculation	3-10
3.7	Multi-Dimensional Arrays.....	3-12
3.8	Application of Arrays	3-12
3.8.1	Addition of Two 2-D Matrices.....	3-12
3.8.2	Transpose of Square Matrix	3-14
3.8.3	Finding whether a given Square Matrix is Symmetrical	3-15
3.8.4	Multiplication of Two Matrices $A_{m \times n}$ and $B_{n \times p}$	3-16
3.8.5	Saddle Point.....	3-17
3.9	Character String in C-Language	3-18
3.9.1	String Comparison.....	3-20
3.9.2	Reversing a String.....	3-20
3.9.3	String Searching.....	3-21
3.9.4	String Concatenation.....	3-22
3.10	Ordered List	3-24
3.11	Representation of a Polynomial of Degree n in an Array	3-25

3.11.1	Pseudo C - Algorithm for Addition of Two Polynomials	3-25
3.11.2	C-Function for Addition of Two Polynomials Represented in an Array	3-26
3.11.3	Representing a Polynomial $A(x, y)$	3-26
3.11.4	Representing a Polynomial $A(x,y,z)$	3-28
3.12	Polynomial as an Ordered List (using Structure)	3-29
3.12.1	Function for Initialisation of a Polynomial.....	3-30
3.12.2	Inserting a Term	3-30
3.12.3	Reading a Polynomial.....	3-31
3.12.4	Printing a Polynomial.....	3-31
3.12.5	Addition of Two Polynomials	3-31
3.12.6	Multiplication of Two Polynomials.....	3-32
3.12.7	Evaluation of a Polynomials	3-33
3.13	Sparse Matrix as an Ordered List	3-36
3.14	Operations on a Sparse Matrix	3-37
3.14.1	From 2D-Representation to Sparse Representation.....	3-37
3.14.2	From Sparse Representation (List of Triplets) to 2D-representation (Conventional).....	3-37
3.14.3	Transpose of a Sparse Matrix (Simple/slow)	3-40
3.14.4	Pseudo-C Algorithm for Simple Transpose.....	3-41
3.14.5	Timing Complexity of the Function Transpose()	3-43
3.15	Fast Transpose	3-43
3.15.1	Pseudo-C Algorithm for Fast Transpose.....	3-45
3.15.2	Calculation of Timing Complexity of "Fast-Transpose()"	3-45
3.15.3	Addition of Two Sparse Matrices	3-46
3.15.4	Multiplication of Two Sparse Matrices	3-48
3.15.5	Applications of Sparse Matrices	3-51
3.16	Representing a Polynomial of Two Variables using Sparse Matrix	3-52
3.17	Case Study - Use of Sparse Matrix in Social Networks and Maps	3-53
3.17.1	Use of Polynomials to Model Economic Growth Pattern	3-53
3.17.2	Polynomial to Describe the Behaviour of Covid-19 Virus.....	3-53

● **Model Question Paper - I (In Sem.) Q-1 to Q-2**

**Unit - III****Chapter 4 : Searching****4-1 to 4-13**

4.1	Searching	4-1
4.2	Sequential - Linear Search	4-1
4.2.1	Sequential Search on a Sorted Array	4-2
4.3	Binary Search.....	4-3
4.3.1	Comparison between Linear and Binary Search.....	4-8
4.4	Fibonacci Search.....	4-8
4.4.1	Binary Search versus Fibonacci search.....	4-9
4.4.2	Selection of Searching Algorithm.....	4-9
4.4.3	Timing Complexity of Fibonacci Search.....	4-10
4.5	Index Sequential Search.....	4-11
4.5.1	Indexing.....	4-11
4.5.2	Sequential File.....	4-12
4.5.3	Indexed Sequential File	4-12
4.6	Sentinel Search.....	4-13
4.7	Case Study - Use of Fibonacci Search	4-13

Chapter 5 : Sorting**5-1 to 5-58**

5.1	Sorting.....	5-1
5.1.1	Sort Stability	5-1
5.1.2	Sort Efficiency	5-2
5.1.3	Passes	5-3
5.1.4	Importance of Sorting and Searching	5-3
5.2	Insertion Sort.....	5-3
5.2.1	Sorting an Array of Strings using Insertion Sort	5-6
5.2.2	Sorting an Array of Records on the given Key using Insertion Sort.....	5-7
5.3	Bubble Sort	5-10
5.4	Selection Sort.....	5-15
5.5	Quick Sort	5-17
5.5.1	Picking a Pivot.....	5-18

5.5.2	Partitioning	5-18
5.5.3	Running Time of Quick Sort	5-31
5.5.3(A)	Worst-Case Analysis for Quick Sort to Sort List of Numbers in Ascending Order	5-32
5.5.3(B)	Best-Case Analysis	5-32
5.5.3(C)	Average-Case Analysis	5-32
5.5.4	Role of Pivot in Efficiency of Quick Sort	5-35
5.6	Two-Way Merge Sort.....	5-35
5.6.1	Merging	5-37
5.6.2	Analysis of Merge Sort	5-44
5.6.3	Non-Recursive Merge Sort	5-45
5.7	Counting Sort	5-45
5.8	Radix Sort	5-47
5.8.1	Algorithm for Radix Sort	5-48
5.8.2	C-Function for Radix Sort	5-48
5.8.3	Analysis of Radix Sort	5-50
5.9	Bucket Sort	5-51
5.10	Shell Sort	5-54
5.10.1	C-Function for Shell Sort	5-54
5.11	External versus Internal Sorting.....	5-56
5.12	Comparison of Sorting Algorithms	5-57
5.13	Best-case, Worst-case and Average-case Analysis of Sorting Algorithm.....	5-58
5.14	Case Study - Timesort is a Hybrid Stable	5-58

Unit - IV**Chapter 6 : Linked List****6-1 to 6-58**

6.1	Representation and Implementation of Singly Linked Lists	6-1
6.1.1	Comparison between Array and Linked Lists.....	6-1
6.1.2	Dynamic Memory Management	6-2
6.1.3	Memory Management Function during Runtime	6-2
6.1.4	Representation	6-3



6.1.5	Implementation.....	6-3	6.3.1	Applications of Circular Linked List.....	6-27
6.1.6	Types of Linked List	6-4	6.4	Doubly Linked List.....	6-27
6.1.6(A)	Singly Linked List	6-4	6.4.1	Creation of a Doubly Linked List.....	6-27
6.1.6(B)	Doubly Linked List	6-5	6.4.2	Deletion of a Node.....	6-31
6.1.6(C)	A Circular Linked List	6-5	6.5	Doubly Linked Circular List.....	6-32
6.2	Basic Linked List Operations	6-5	6.6	Applications of Linked Lists	6-34
6.2.1	Creating a Linked List.....	6-6	6.6.1	Polynomials as Linked Lists	6-34
6.2.2	Traversing a Linked List	6-7	6.6.2	Addition of Two Polynomials	6-35
6.2.3	Counting Number of Nodes in a Linked List through Count Function.....	6-7	6.7	Concept of Skip List	6-41
6.2.4	Printing a List through Print Function.....	6-8	6.8	Generalized Linked List	6-41
6.2.5	Inserting an Item	6-8	6.8.1	Introduction	6-41
6.2.5(A)	Inserting an Item at the End of a Linked List.....	6-9	6.8.2	Representation of Generalized Lists.....	6-42
6.2.5(B)	Inserting a Data 'x' at a given Location 'LOC' in a Linked List, Referenced by 'head'	6-10	6.9	Representation of Polynomial using Generalized List	6-47
6.2.5(C)	Inserting an Element in a Priority Linked List.....	6-12	6.10	Linked List in Array.....	6-54
6.2.6	Deleting an Item	6-13	6.11	Memory Allocation.....	6-54
6.2.6(A)	Deletion of the Last Node of a Linked List	6-14	6.11.1	First-Fit Allocation	6-54
6.2.6(B)	Deletion of a Node at Location 'LOC' from a Linked List.....	6-14	6.11.1(A)	Algorithm for First-Fit.....	6-55
6.2.6(C)	Delete a Linked List, Referenced by the Pointer Head	6-15	6.11.2	Best-Fit Allocation	6-56
6.2.7	Concatenation of Two Linked Lists	6-16	6.11.2(A)	Algorithm for Best-Fit.....	6-57
6.2.8	Inversion of Linked List.....	6-16	6.11.3	Worst Fit	6-57
6.2.9	Searching a Data 'x' in a Linked List, Referenced by the Pointer Head	6-18	6.11.4	Next Fit.....	6-57
6.2.10	Searching an Element x in a Sorted Linked List	6-19	6.12	Garbage Collection.....	6-57
6.2.11	New Linear Linked List by Selecting Alternate Element.....	6-19	Unit - V		
6.2.12	Handling of Records through Linked List	6-20			
6.2.13	Merging of Sorted Linked Lists	6-20			
6.2.14	Splitting a Linked List at the Middle and Merge with Second Half as First Half.....	6-21			
6.2.15	Removing Duplicate Elements from a Linked List.....	6-22			
6.3	Circular Linked List.....	6-23			

Chapter 7 : Stacks**7-1 to 7-60**

7.1	Introduction	7-1
7.2	Operations on Stacks	7-2
7.3	Array Representation.....	7-2
7.3.1	'C' Functions for Primitive Operations on a Stack.....	7-2
7.3.2	Program Showing Stack Operations.....	7-3
7.3.3	Operations on Stack Considering Overflow and Underflow : [Array Implementation]	7-5



7.4	Linked Representation of a Stack	7-6	7.10.4	Searching a Number in an Array	7-54
7.4.1	Functions for Stack Operations	7-7	7.10.5	Finding Largest Element in an Array.....	7-54
7.5	Application of Stack.....	7-8	7.10.6	Binary Search.....	7-54
7.5.1	Expression Representation.....	7-9	7.10.7	Tower of Hanoi Problem.....	7-54
7.5.2	Evaluation of a Postfix Expression using a Stack	7-9	7.11	Backtracking.....	7-57
7.5.3	Evaluation of a Prefix (Polish) Expression	7-12	7.12	Variants of Recursion	7-57
7.5.3(A)	Conversion of an Expression from Infix to Postfix....	7-15	7.13	Backtracking Algorithmic Strategy	7-58
7.5.4	Conversion of an Expression from Infix to Prefix	7-26	7.13.1	Use of Stack in Backtracking.....	7-58
7.5.5	Conversion of Expression from Postfix into Infix.....	7-29	7.13.2	Removal of Recursion	7-58
7.5.6	Conversion of Expression from Postfix into Prefix	7-31	7.14	Case Study : The n-queens Problem (8 Queen as a Case)	7-58
7.5.7	Conversion of Expression from Prefix to Infix	7-33	7.15	Case Study : Android-Multiple Tasks / Multiple Activities and Back Stack	7-60
7.5.8	Conversion of Expression from Prefix into Postfix	7-35	Unit - VI		
7.5.9	Fully Parenthesizing an Infix Expression	7-37			
7.5.10	Conversion of a Fully Parenthesized Infix Expression into Postfix	7-40			
7.5.11	Conversion of a Fully Parenthesized Infix Expression into Prefix Form.....	7-43	Chapter 8 : Queues		
7.5.12	Well Formedness of Parenthesis.....	7-47	8-1 to 8-35		
7.5.12(A)	Algorithm to Read in a Parenthesized Infix Expression and Check Well-formedness of Parenthesis.....	7-47	8.1	Array Implementation of Queues.....	8-1
7.6	Representation of Two Stacks in an Array.....	7-48	8.1.1	Definition	8-1
7.7	Representation of Multiple Stacks in an Array	7-49	8.1.2	Application of Queues	8-1
7.8	Recursion	7-50	8.1.3	Array Representation and Implementation of Queues	8-1
7.8.1	Introduction	7-50	8.2	Operations on Queue	8-3
7.9	Converting a Recursive Function to an Equivalent C-Function.....	7-51	8.2.1	Operations on Queue Implemented using Array	8-3
7.9.1	Finding Factorial of an Integer Number	7-51	8.2.2	Queue as an ADT.....	8-6
7.10	Examples of Recursion.....	7-52	8.2.3	Operations on Queue Implemented using Linked Structure	8-8
7.10.1	Finding Sum of the Elements Stored in an Array	7-53	8.3	Circular Queues	8-13
7.10.2	Finding Length of a String	7-53	8.3.1	Queue using a Circular Array	8-13
7.10.3	Reversing a String.....	7-53	8.3.1(A)	Implementation of a Circular Movement inside a Linear Array.....	8-14



8.3.2	Queue using a Circular Linked List	8-17	8.7.1	Josephus Problem.....	8-32
8.4	Dequeues.....	8-22	8.7.2	Job Scheduling.....	8-33
8.4.1	Implementation of Dequeue using a Circular Array....	8-23	8.7.3	Queue Simulation.....	8-34
8.5	Priority Queue	8-27	8.8	Case Study - Priority Queue in Bandwidth Management	8-34
8.5.1	Implementation of Priority Queues	8-27	● Model Question Paper - I (End Sem.) Q-1 to Q-2		
8.6	Representation of Multiple Queues in an Array.....	8-31			
8.7	Applications of Queue	8-32			

□□□