Printed Page:- 06 Subject Code:- AMICA0501

Roll. No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

MCA (Integrated)

SEM: V - THEORY EXAMINATION (2024- 2025)

Subject: Design and Analysis of Algorithms

Time: 3 Hours Max. Marks: 100

General Instructions:

IMP: *Verify that you have received the question paper with the correct course, code, branch etc.*

1. This Question paper comprises of three Sections -A, B, & C. It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.

2. Maximum marks for each question are indicated on right -hand side of each question.

3. Illustrate your answers with neat sketches wherever necessary.

4. Assume suitable data if necessary.

5. Preferably, write the answers in sequential order.

6. No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION-A 20

1. Attempt all parts:-

1-a. What is the primary goal of problem definition in algorithm design? (CO1,K1) 1

(a) To write code for the problem.

(b) To understand the input, output, and constraints of the problem.

(c) To analyze the algorithm's complexity.

(d) To measure the algorithm's performance.

1-b. The time complexity of an algorithm in the worst-case scenario is described by which asymptotic notation? (CO1,K1) 1

(a) Omega Notation

(b) Theta Notation

(c) Big-O Notation

(d) Little-o Notation

1-c. In Counting Sort, which type of data distribution is best suited for optimal performance? (CO2,K1) 1

(a) Uniformly distributed data within a small range

(b) Randomly distributed data within a large range

(c) Uniformly distributed floating-point data

(d) Data with many unique characters

1-d. What is the primary disadvantage of the Naive String Matching algorithm? (CO2,K1) 1

(a) It requires extra space for hashing.

(b) It performs unnecessary comparisons, leading to high time complexity.

(c) It cannot handle large inputs.

(d) It is only suitable for numerical patterns.

1-e. Strassen's Matrix Multiplication is more efficient than traditional matrix multiplication because it: (CO3,K1) 1

(a) Uses divide and conquer to reduce the number of multiplications

(b) Uses brute-force to multiply matrices faster

(c) Uses fewer additions than multiplications

(d) Does not require matrix inversion

1-f. In the Fractional Knapsack problem, the best approach is to: (CO3,K1) 1

(a) Take items with the highest weight first

(b) Take items with the highest value first

(c) Take items with the highest value-to-weight ratio first

(d) Take items with the lowest weight first

1-g. Dynamic programming is primarily used to solve problems with which of the following characteristics? (CO4,K1) 1

(a) No overlapping subproblems

(b) Optimal substructure

(c) No recursive solution

(d) No overlapping substructure

1-h. Warshall's Algorithm is used for: (CO4,K1) 1

(a) Finding the transitive closure of a graph

(b) Finding shortest paths in a weighted graph

(c) Sorting an array

(d) Finding a minimum spanning tree

1-i. In an undirected graph, the number of edges connected to a node is called its: (CO5,K1) 1

(a) Degree

(b) Weight

(c) Depth

(d) Height

1-j. Which traversal method visits the left subtree, then the root, and then the right subtree? (CO5,K1) 1

(a) Pre-order

(b) In-order

(c) Post-order

(d) Breadth-First

2. Attempt all parts:-

2.a.	Explain the purpose of problem definition in algorithm design, Is it so important? (CO1,K1)	2
2.b.	Write the main requirements for using Binary Search and suggest if the requirement fails, how can that be improved? (CO2,K1)	2
2.c.	Explain why is Merge Sort preferred over Quick Sort for linked lists? (CO3,K2)	2
2.d.	Describe the Resource Allocation Problem in the context of Dynamic Programming. (CO4,K2)	2
2.e.	Differentiate between undirected and directed graphs. (CO5,K2)	2

SECTION-B 30

3. Answer any five of the following:-

3-a.	Explain the different types of asymptotic notations used to express algorithm complexity. Provide an example for each. (CO1,K2)	6
3-b.	Solve the following recurrence relation using the recursion tree method: $T(n)=2T(n/2)+n$. (CO1,K4)	6
3-c.	Explain the Bubble Sort algorithm. Provide its time complexity and illustrate it with an example. (CO2,K2)	6
3-d.	Explain BST using 40,15,60,79,10,53,1,12,25,55 , write an algorithm of it, and write its time complexity. (CO2,K2)	6
3.e.	Explain the Convex Hull problem and the algorithms used to solve it. Discuss the time complexity of Convex Hull algorithms. (CO3,K3)	6
3.f.	Explain the Longest Common Subsequence (LCS) problem and solve the following instance using Dynamic Programming: Given sequences X = "AGGTAB" and Y = "GXTXAYB", find the length of the LCS and the actual subsequence. (CO4,K3)	6
3.g.	Consider the following graph: Vertices: A, B, C, D, E Edges: A-B, A-C, B-D, C-E, B-E, C-D, A-F, E-F, E-H, F-H, D-G Perform a Depth-First Search (DFS) traversal starting from vertex A. List the vertices in the order they are visited and discuss the time complexity of DFS. Explain the difference between DFS and BFS. (CO5,K3)	6

SECTION-C 50

4. Answer any one of the following:-

4-a.	Solve the following recurrence relation using the substitution method: $T(n)=3T(n/4)+O(n)$, where $T(1)=O(1)$. Substitution: Explain how to solve the recurrence relation step by step using substitution. Show the detailed steps of applying the substitution method. Derive the time complexity of the algorithm and express it in Big-O notation. Discuss how the solution relates to the efficiency of divide and conquer	10

algorithms. (CO1,K3)

4-b. Use the Master Theorem to solve the following recurrence: T(n)=3T(n/4)+n^2 10
Compare the given recurrence with the general form
T(n)=aT(n/b)+O(n^d).
Identify the values of a, b, and d.
Apply the Master Theorem to solve the recurrence and find the asymptotic time complexity.
Discuss the conditions under which the recurrence might fall into different cases of the Master Theorem. (CO1,K3)

5. Answer any <u>one</u> of the following:-

5-a. Given the array: [4, 2, 2, 8, 3, 3, 1, 5, 4, 6] 10
Sort the array using Counting Sort.
Show all the intermediate steps, including the counting of elements and the construction of the output array.
What is the time complexity of Counting Sort in terms of Big-O notation?
Explain the space complexity of Counting Sort and any constraints on the input. (CO2,K3)

5-b. Given the array: 10
[15, 7, 9, 3, 6, 12]

Sort the array using Insertion Sort.
Explain the inner loop workings and how each element is inserted in the correct position in the sorted portion.
Determine the number of comparisons and shifts that occur during the sorting process.
What is the time complexity in the best, worst, and average cases for Insertion Sort? (CO2,K4)

6. Answer any <u>one</u> of the following:-

6-a. Consider the following weighted graph: Consider following (Vertex---Edge) Pairs 10
A---B = 4
A---D = 2
B---D = 3
B----C = 1
B---E = 5
D---E= 1
E---G = 3
C---G = 6
A---G = 4
B---G = 2

Find the shortest path from A to all other vertices using Dijkstra’s Algorithm.
Show the process of selecting vertices and updating the shortest paths.
What is the time complexity of Dijkstra’s algorithm using a priority queue or Fibonacci heap?

Compare Dijkstra's algorithm with Bellman-Ford in terms of time complexity and applicability. (CO3,K3)

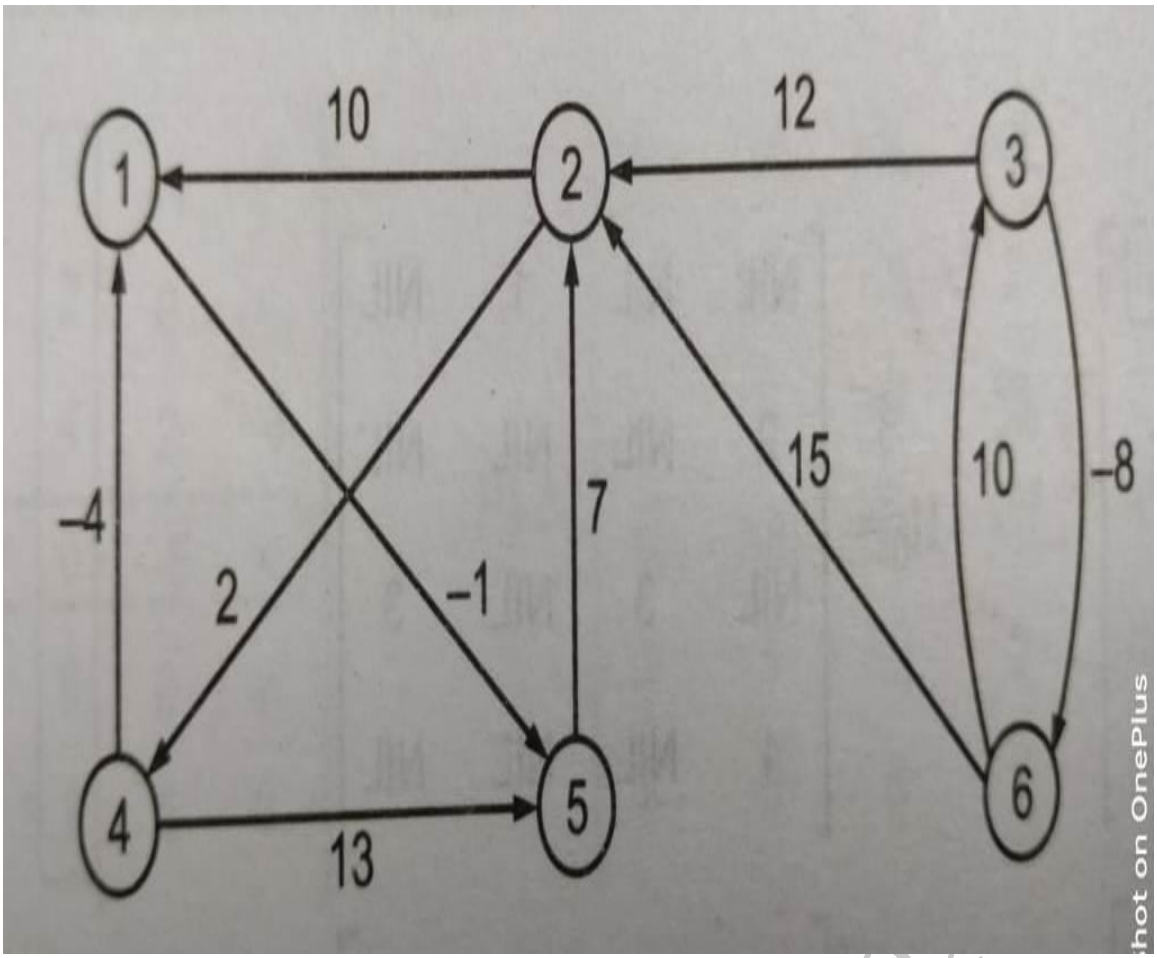
6-b. Given the following set of characters and their frequencies: 10
[(A, 5), (B, 9), (C, 12), (D, 13), (E, 16), (F, 45)]

Construct the Huffman Tree using the given frequencies.
Show the steps involved in merging nodes and creating the final tree.
Generate the Huffman codes for each character based on the tree structure.
What is the time complexity of building the Huffman Tree? Discuss how this algorithm can be applied in data compression. (CO3,K6)

7. Answer any <u>one</u> of the following:-

7-a. Given the following undirected graph: 10
Vertices: {A, B, C, D, E}
Edges: (A, B), (A, C), (A, D), (B, C), (B, E), (C, D), (D, E)
Color the graph using the Branch and Bound technique to find the minimum number of colors required.
Show the branching process, including the bounds for each color assignment.
Determine the minimum number of colors required for the graph.
What is the time complexity of the Branch and Bound method in solving the graph coloring problem?
Discuss the applications of graph coloring in real-world scenarios, such as scheduling problems. (CO4,K3)

7-b. Consider the following Graph G(V,E), Apply all pair shortest path algorithm for generating a result. (CO4,K3) 10



8. Answer any <u>one</u> of the following:-

8-a. Solve the 4-Queens problem using Backtracking. 10

Place four queens on a 4x4 chessboard such that no two queens threaten each other. Show all the valid configurations.
Construct the state space tree for the problem and explain the pruning of invalid branches.
Solve the 8-Queens problem using the same approach, and explain the difference in the complexity of the two problems.
Determine the time complexity of solving the N-Queens problem using backtracking.
How does the solution for 8-Queens compare with the 4-Queens problem in terms of solution space and branching factor?
(CO5,K3)

8-b. Show the resulting of inserting 10
1,22,24,26,28,30,14,15,33,36,55,7,4,44,56,68,73,84,69,79,80,81 in this order into an B Tree with t=3. (CO5,K3)