Printed Page:- 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. In the example algorithm to find the maximum element in a list, which of the following is NOT a step? (CO1,K1) 1

(a) Initialize max_value to the first element.

(b) Iterate through each element in the list.

(c) Sort the list in ascending order.

(d) Return max_value after completing the loop.

1-b. Which of the following data structures is used in a Breadth-First Search (BFS)? (CO1,K1) 1

(a) Stack

(b) Queue

(c) Priority Queue

(d) Hash Map

1-c. What is the main advantage of the Rabin-Karp algorithm for string matching? (CO2,K1) 1

(a) It always has a time complexity of O(m+n).

(b) It avoids collisions entirely.

(c) It uses a hashing technique to find the pattern faster.

(d) It is the fastest string-matching algorithm in all cases.

1-d. Which sorting algorithm uses a similar method as the one used by card players to 1

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arrange their hand? (CO2,K1)

(a) Selection Sort

(b) Bubble Sort

(c) Insertion Sort

(d) Counting Sort

1-e. Which of the following algorithms does NOT use the Greedy Method? (CO3,K1) 1

(a) Prim's Algorithm

(b) Dijkstra's Algorithm

(c) Kruskal's Algorithm

(d) Merge Sort

1-f. The Bellman-Ford Algorithm can handle graphs with: (CO3,K1) 1

(a) Only positive edge weights

(b) Only negative edge weights

(c) Both positive and negative edge weights

(d) No weights at all

1-g. The Dynamic Programming table for Matrix Chain Multiplication requires space of: (CO4,K1) 1

(a) O(n)

(b) O(nlogn)

(c) O(n^2)

(d) O(n^3)

1-h. What is the main idea behind Floyd-Warshall Algorithm? (CO4,K1) 1

(a) Recursively solving for the shortest path between vertices.

(b) Iteratively updating the shortest paths between every pair of vertices using intermediate vertices.

(c) Using a greedy approach to find the shortest paths.

(d) Splitting the graph into subproblems and using a divide-and-conquer approach.

1-i. A tree is a special type of graph that is: (CO5,K1) 1

(a) Directed and weighted

(b) Connected and acyclic

(c) Undirected and cyclic

(d) Weighted and cyclic

1-j. In a balanced binary search tree (BST), the time complexity of searching for a value is: (CO5,K1) 1

(a) O(n)

(b) O(logn)

(c) O(n^2)

(d) O(1)

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2. Attempt all parts:-

2.a.	Explain Omega (Ω) notation and its significance. (CO1,K1)	2
2.b.	How does the Rabin-Karp algorithm improve on Naive String Matching? (CO2,K2)	2
2.c.	Find the Convex Hull for the points (0,3),(2,2),(1,1),(2,1),(3,0),(0,0),(3,3). (CO3,K3)	2
2.d.	Given matrices with dimensions =10×30, =30×5, =5×60, find the minimum number of scalar multiplications needed to multiply these matrices. (CO4,K3)	2
2.e.	Discuss all the different rotations done during an AVL tree - insertion and deletion.? Explain then with example. (CO5,K2)	2

SECTION-B 30

3. Answer any five of the following:-

3-a.	Discuss why do we use asymptotic notation in study of algorithm? Describe various asymptotic notations and give their significance? (CO1,K1)	6
3-b.	Solve the following recurrences, where T(1) = 1 and T(n) for n>=2 satisfies. T(n) = 9T(n/3) + n^3. (CO1,K3)	6
3-c.	Discuss the working of the Selection Sort algorithm with an example and explain its time complexity in all cases. (CO2,K2)	6
3-d.	Explain the Rabin-Karp string matching algorithm. How does it improve over the Naive approach? What is the worst-case time complexity? (CO2,K3)	6
3.e.	Given the following items with weights and values: Item 1: weight = 4, value = 12 Item 2: weight = 2, value = 10 Item 3: weight = 3, value = 14 The knapsack has a capacity of 5. Using the Greedy approach, determine the maximum value that can be obtained by selecting items. Show the steps and calculate the total value. (CO3,K5)	6
3.f.	Traveling Salesman Problem (TSP) with 4 Cities Use the Branch and Bound approach to solve the Traveling Salesman Problem for the following cities with distance matrix: A-B (10), A-C (15), A-D (20) B-C (35), B-D (25) C-D (30) Find the shortest path visiting all cities once and returning to the start. Explain the bounding process and pruning decisions. (CO4,K3)	6
3.g.	Given a set of numbers {3, 4, 5, 6} and a target sum of 9, find all subsets of the set that sum to the target using the Subset Sum Problem. Illustrate how Dynamic Programming or backtracking can be used to solve this problem. (CO5,K3)	6

SECTION-C 50

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

4-a.	Write an algorithm to solve the Maximum Subarray Problem, which finds the contiguous subarray with the largest sum in a given integer array. (CO1,K3)	10
4-b.	Solve the following recurrence using the Master Theorem: T(n)=2T(n/3)+nlogn Identify the values of a, b, and d in the given recurrence. Determine the complexity of the recurrence by comparing the terms as per the Master Theorem's cases. Explain the steps to apply the theorem in detail and find the time complexity. Discuss any edge cases or constraints for which the Master Theorem might not apply directly. (CO1,K2)	10

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

5-a.	Consider the string text = "ABCABAACAB" and the pattern pattern = "ABA". Use the Rabin-Karp Algorithm for string matching, where a hash function is used to compare substrings. Calculate the hash values for the pattern and the substrings of the text of the same length. Match the hashes and check for exact matches of the pattern in the text. What is the average-case time complexity of the Rabin-Karp algorithm, assuming that hash collisions are rare? How does the Rabin-Karp algorithm improve the efficiency of string matching compared to the Naive String Matching algorithm? (CO2,K3)	10
5-b.	Given the following sequence of integers to insert into an initially empty Binary Search Tree (BST): [50, 30, 20, 40, 70, 60, 80] Insert these elements into a Binary Search Tree. Show the final structure of the Binary Search Tree (BST) after all insertions. Perform an in-order traversal of the BST and list the elements in ascending order. Analyze the time complexity of inserting an element into a Binary Search Tree in terms of Big-O notation for the best case, average case, and worst case. (CO2,K3)	10

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

6-a.	Given two matrices: Matrix A (2x2): [1, 2] [3, 4] Matrix B (2x2): [5, 6] [7, 8] Multiply the matrices using Strassen's Matrix Multiplication algorithm. Break down the multiplication into subproblems and show the intermediate steps. Explain how Strassen's algorithm reduces the number of multiplications compared to traditional matrix multiplication. What is the time complexity of Strassen's algorithm compared to the naive matrix multiplication approach? Discuss the trade-offs in terms of space complexity and the use of Strassen's	10

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algorithm in practical applications. (CO3,K3)

6-b. Consider the following weighted graph: 10

A--B = 2
A--C = 6
B--D = 5
C--D = 1
B--E = 2
D--E = 1
A--E = 2
D--F =2
E--F = 2

Find the minimum spanning tree (MST) using Prim's Algorithm starting from vertex A.
Show all intermediate steps of the algorithm, including the edges selected at each step.
What is the time complexity of Prim's algorithm using an adjacency matrix and adjacency list representation?
How does Prim's algorithm perform compared to Kruskal's Algorithm? (CO3,K3)

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

7-a. Given the following sequence of matrices: 10

Matrix A: 10 x 20
Matrix B: 20 x 30
Matrix C: 30 x 40
Matrix D: 40 x 30

Find the optimal order for matrix chain multiplication using Dynamic Programming.
Show the cost matrix and the split matrix used for computing the minimum number of scalar multiplications.
How many scalar multiplications are needed to multiply the matrices in the optimal order?
What is the time complexity of Matrix Chain Multiplication using this DP approach?
How does this approach compare to naive recursion in terms of both time and space complexity? (CO4,K3)

7-b. Determine the LCS algorithm on A (1,0,0,1,0,1,0,1) and B (0,1,0,1,1,0,1,1,0) tp find the longest common sequence in A and B. (CO4,K3) 10

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

8-a. Show the resulting of inserting 10,18,7,15,16,30,25,40,60,6,59 in this order into an RB Tree. (CO5,K3) 10

8-b. Construct the m-way tree corresponding to following insertions (8,14,2,15,3,1,16,6,5,27,37,18,25,7,13,20,22,23,24,16,18,17,3) Consider the tree size of Order = 4. (CO5,K3) 10

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