PG/1st Sem/MCI/25

2025

M.Tech. 1st Semester Examination

COMPUTER SCIENCE WITH AI

Paper : MCIC404X0

[Advanced Algorithms]

Full Marks : 100 Time : Three Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group - A

Answer any *five* questions : 2×5=10

1. Define time and space complexity with one illustrative example.
2. Write the general form of a recurrence relation for divide-and-conquer algorithms.
3. What is the principle of optimality in dynamic programming?
4. Name the two greedy algorithms used for finding Minimum Spanning Trees.
5. What do you mean by backtracking in algorithm?
6. Why is amortized analysis useful in algorithm analysis?

P.T.O.

7. What is the difference between NP-Hard and NP-Complete problems?

8. Define the classes P and NP with examples.

Group - B

Answer any ***four*** questions : 15×4=60

9. (i) Explain the partitioning strategy used in Quick Sort. What is the worst-case time complexity and how can it be avoided?

   (ii) Solve the Longest Common Subsequence (LCS) problem for strings X = "AGGTAB" and Y = "GXTXAYB" using dynamic programming. Show the LCS table and the actual LCS. (4+4)+7

10. (i) Solve the Matrix Chain Multiplication problem for matrices with dimensions : $M_1(10\times20)$, $M_2(20\times30)$, $M_3(30\times20)$, $M_4(20\times40)$ using dynamic programming and show the optimal parenthesization and minimum number of scalar multiplications.

    (ii) What is the time complexity of the Matrix Chain Multiplication algorithm? Justify your answer. 12+3

11. (i) Explain the Floyd-Warshall algorithm for finding all pairs shortest paths. Apply the algorithm on the following graph and show the intermediate matrices :
    Graph with 4 vertices {A, B, C, D}
    Edges : $A \rightarrow B(3)$, $A \rightarrow C(8)$, $A \rightarrow D(\infty)$,
    $B \rightarrow D(1)$, $C \rightarrow B(4)$, $D \rightarrow A(2)$, $D \rightarrow C(-5)$

(ii) Discuss the applicability of Floyd-Warshall algorithm for graphs with negative edge weights. 12+3

12. (i) Solve the 0/1 Knapsack problem using dynamic programming for the following data :
Knapsack capacity W = 8
Items : {weight, value} = {(2, 1), (3, 2), (4, 5), (5, 6)}
Show the DP table and determine which items should be selected.

(ii) Why cannot the Greedy approach guarantee an optimal solution for the 0/1 Knapsack problem? 12+3

13. (i) Solve the Fractional Knapsack problem using the greedy approach for the following data :
Knapsack capacity W = 50
Items : {weight, profit} = {(10, 60), (20, 100), (30, 120)}

Calculate the maximum profit obtainable.

(ii) Explain Kruskal's algorithm for finding the Minimum Spanning Tree using a graph of your choice with at least 6 vertices. 7+8

14. (i) Explain the Ford-Fulkerson algorithm for maximum flow in networks with its complexity.

P.T.O.

(ii) Find the maximum flow for the following network :
Edges : $S \rightarrow A(10)$, $S \rightarrow B(8)$, $A \rightarrow B(5)$,

$A \rightarrow T(5)$, $B \rightarrow T(10)$.

Show each augmentation step.

(iii) Describe the reduction technique used to prove a problem as NP-Complete. Give an example.

5+5+5

15. (i) Explain the Stable Marriage problem and the Gale-Shapley algorithm. Apply the algorithm for the following preference lists :
Men : M1 prefers {W2, W1, W3}, M2 prefers {W1, W2, W3}, M3 prefers {W2, W3, W1}

Women : W1 prefers {M2, M1, M3}, W2 prefers {M1, M3, M2}, W3 prefers {M1, M2, M3}
Show that the resulting matching is stable.

(ii) How is the Hospital-Resident problem related to the Stable Marriage problem? 12+3

16. (i) Explain the N-Queens problem and the backtracking approach to solve it. Illustrate the solution for N = 4 using a state-space tree.

(ii) How does forward checking improve the efficiency of backtracking? 12+3

Internal Assessment - 30 marks