B.E. COMPUTER SCIENCE AND ENGINEERING THIRD YEAR SECOND SEMESTER - 2025

Subject: DESIGN AND ANALYSIS OF ALGORITHMS

Time: 3 hours | Full Marks: 100

Answer question no. **1 or 2** from Group A and question no. **3 or 4** from Group B and question no. **5 or 6** from Group C and question no. **7 or 8** from Group D

Group A

(Answer question no. 1 or 2 from this group)

[CO1]

1. a) Compute the time complexity of the following code:

```
int fun(int n)
  {int count = 0;
   for (int i = n; i > 0; i /= 2)
     for (int j = 0; j < i; j++)
         count += 1;
   return count;
  }
```

b) Use substitution method for solving the following recurrence equation:
$T(n) = 6T(n/2) + O(n)$, T(1)= 1.

c) Show that the running time of the BFS algorithm is O(n) when adjacency list and queue data structure are used, and the input graph is minimally connected.

d) Prove that $n!$ belongs to $\Omega(2^n)$

e) What is called pseudo polynomial time complexity? Give an example. **5 x 5 = 25 marks**

2. a) Compute the time complexity of the following code:

```
int fun(int n) {
        int i, j;
        for (i = 1; i < = n; i++) {
        for (j = 1; j < n; j + = i) {
                        printf (" %d %d", i, j);
        }
        }
}
```

b) Use ***recursion tree*** method for solving the following recurrence:
$T(n) = 4T(n/2) + O(n)$, T(1)= 1.

c) Why should we study algorithms? Write at least four reasons.

d) Breadth First Search (BFS) is a fundamental graph traversal algorithm. Justify with an example why is it called " Breadth First "?

e) For a given problem, student X has developed an algorithm X and student Y has developed an algorithm Y. The students X and Y have computed T(n) for these two algorithms, which are $\log(n)$ *and* $\sqrt{n}$ respectively. Finally, they concluded that both algorithms belong to O(n). Is this conclusion wrong? Justify. In this case, which algorithm will you choose for code implementation and why? **5 x 5 = 25 marks**

Group B
[CO2]
(Answer question no. 3 or 4 from this group)

3. a) Write the Quicksort algorithm. Compute the worst case time complexity of this algorithm

b) Does quicksort algorithm follow all steps of "Divide and Conquer" Approach" ? Explain.
Can we solve T(n)= 2T(n-1) + O(1) using Master theorem? If yes, solve it using the master theorem, but If not, justify and solve it using any method you know.

c) Consider the following recurrence equation:
For some constant c, $T(n) \leq q\, T(n/2) + cn$ when $n>2$, and $T(2) \leq c$.
Use recursion tree show that T(n) with $q>2$ is bounded by $O(n^{\log_2 q})$.

10 + 5+10= 25 marks

4. a) Write MergeSort Algorithm. Show the detailed analysis of this algorithm.
b) Does MergeSort algorithm follow all steps of "Divide and Conquer" Approach" ? Explain
Use Master theorem to find the value of the following recurrence:

$$T(n) = 5T(n/5) + O(\sqrt{n}),\ T(1) = 1,\ T(0) = 0$$

c)For some divide and conquer algorithms, the combination step is costlier than the division step and, for some divide and conquer algorithms, the division step is costlier than the combination step- Justify this statement with examples.
d) Consider the event "the chosen pivot gives a 25-75 split or better" for the Quicksort algorithm. What is the probability of this event? 10 + 5 x 3 = 25 marks

Group C
[CO3 and CO4]
(Answer question no. 5 or 6 from this group)

5. a) Consider the following graph search algorithm and analyze its running time in detail.

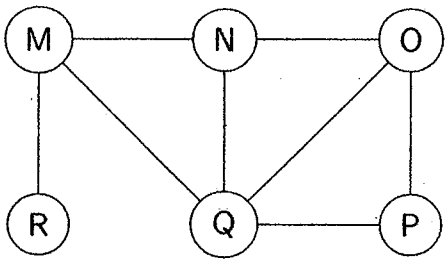
Graph-search(G) \\G=(V, E) and
\\G is implemented using list
Assumptions: do not allow visiting any node twice\\
Step1. Mark a node as S and Explored= {S}, Unexplored= ( ).
Step2. Search for an edge E= (u, v) where u∈ Explored, v ∈ Unexplored
if ∃*E*, mark v and Explored= Explored ∪ v
Step3: Stop where |explored|= |v|

b) Show with an example that the greedy algorithm for coin changing problem does not always give an optimal solution.

c) Explain the Dijkstra's shortest path finding algorithm with a suitable example. Does it work for any types of graph?-explain 5+5+15=25 marks

6. a) How is the following graph represented using the adjacency list method? The *Breadth First Search (BFS)* algorithm has been implemented using the queue data structure. Which one of the following is a possible order of visiting the nodes in the graph below? Justify with reasons which choices you consider "wrong" and which one you consider" right?

A. *MNOPQR* **B.** *NQMPOR* **C.** *QMNROP* **D.** *POQNMR*



b) What is called "Cut" for a graph? Explain why the Prim's algorithm for finding MST is a greedy algorithm.
Write the implementation of the Prim's algorithm using Priority queue. Give a suitable example to show how it works.

10 +15 = **25 marks**

Group D

(Answer question no. 7 or 8 from this group) **[CO5 and CO6]**

7. a) Explain the dynamic programming approach to solving the problem of finding longest increasing subsequence from a list of integer numbers. Compute its time complexity.

b) What is the difference between "NP-complete" and "NP-hard" problems. Explain with examples.

c) Give the analysis of the randomized algorithm for selection

10+5 +10 = **25 marks**

8. a) Explain the dynamic programming approach to solving the problem of finding minimum edit distance between two strings. Compute its time complexity.

b) If any of the NP complete problem can be solved in polynomial time, then P = NP. Is this statement correct? If it is yes, explain how can we prove P=NP. but if no, explain why not?

c) Write the randomized algorithm for selection.

10 + 5 + 10 = **25 marks**