COMSATS University Islamabad, Attock Campus
Department of Computer Science

Program: SE IV

Fall 2024: Terminal Examination

Course: - Data Structures and Algorithms

Time Allowed: - 180 Minutes **Marks: 55**

Name:- _____ Regn. No:-_____

Note:- Don't write anything on Question Paper except your Name & Regn. No.

Q1. A logistics company manages its delivery tasks using a **priority queue** system. Each delivery task is assigned a priority based on the following criteria:

- **Urgent Deliveries (Priority 1):** Same-day delivery within city limits.
- **Standard Deliveries (Priority 2):** Next-day delivery within the city.
- **Bulk Deliveries (Priority 3):** Delivery of large shipments with flexible timing.

The company handles tasks in order of priority; ensuring urgent deliveries are completed first. If two tasks have the same priority, they are handled in the order they were added to the queue.

1. **Explain** why a priority queue is the most appropriate data structure for managing these deliveries, and justify your reasoning with relevant features of a priority queue.
2. If the company receives the following delivery requests in order:
   Task A: Urgent delivery
   Task B: Bulk delivery
   Task C: Standard delivery
   Task D: Urgent delivery
   Determine the order in which tasks will be processed by the priority queue, and provide an explanation for your answer.

[CLO1: Employ linear data structures to solve computing problems.] (10 Marks)

Q2. A university is organizing an online course registration system where students register for courses. To ensure efficient management, an **AVL Tree** is used to store and retrieve student records. Each record is represented by a unique student ID (integer).
The system requires the following operations:

- **Insert a new student record:** Add a student to the system while ensuring the tree remains balanced.
- **Search for a student record:** Quickly retrieve details of a student using their ID.

1. **Illustrate** how an AVL Tree ensures efficiency in handling these operations compared to an unbalanced binary search tree.
2. If the following student IDs are inserted in the given order:
   50, 30, 70, 20, 40, 60, 80
   Determine the structure of the AVL Tree after all insertions, and explain the rotations (if any) performed to maintain balance.

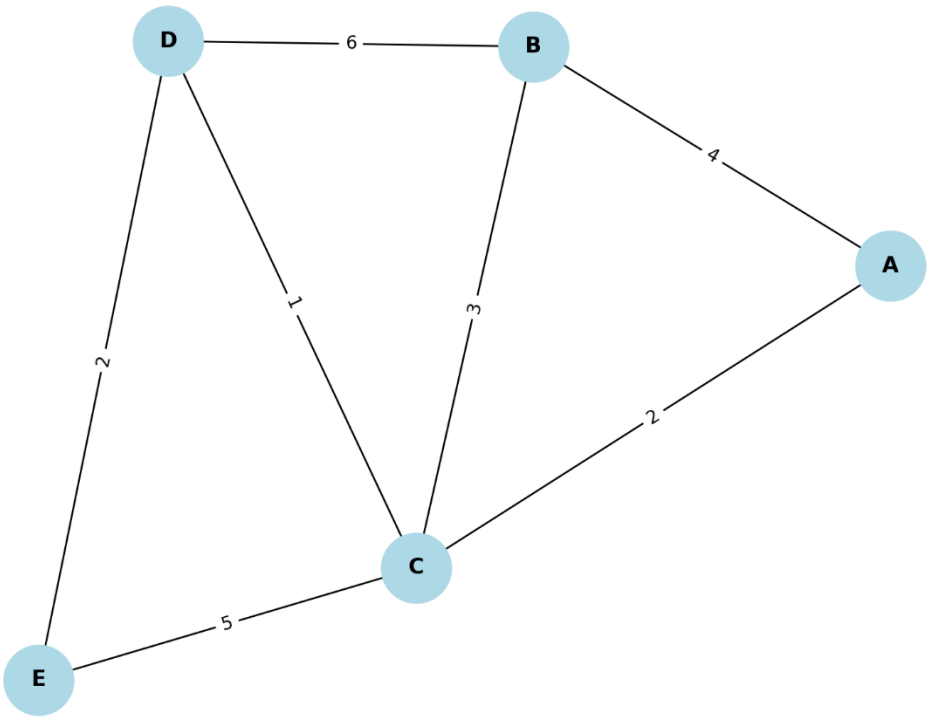
[CLO2: Use non-linear data structures to solve computing problems.] (10 Marks)

Q3: A city's transportation department is designing an efficient transportation network to minimize travel costs and times between various neighborhoods. The city is represented as a **graph**, where:

- **Nodes** represent neighborhoods.
- **Edges** represent roads connecting the neighborhoods, with weights indicating the travel cost or time.

The department has the following objectives:

1. Find the shortest path from the central hub (Node A) to other neighborhoods for efficient delivery services.
2. Minimize the overall cost of connecting all neighborhoods using a minimum number of roads.



a) Determine the shortest paths from the central hub (Node A) to all other neighborhoods using Dijkstra's algorithm, and explain the steps involved.

b) Apply Kruskal's algorithm to construct a Minimum Spanning Tree (MST) for the transportation network. List the edges selected in the MST and justify the inclusion of each edge.

[CLO2: Employ npn-linear data structures to solve computing problems.] (7+8 Marks)

Q4: Sort the following array using both **Bubble Sort** and **Merge Sort**, and show the step-by-step process for each:
Input Array: [8, 3, 1, 7, 0, 10, 2]
Analyze the number of comparisons made in the **worst-case** scenario for each algorithm. Write the pseudocode and use it to determine the time complexity for:

- **Bubble Sort**
- **Merge Sort**

Compare and contrast the computational efficiency of these algorithms for **large input sizes** using their respective Big-O notations.

(20 Marks)

[CLO3: Analyze the time complexity of various algorithms.]