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University Examinations 2024/2025

FIRST YEAR FIRST SEMESTER FOR THE DEGREE OF MASTER OF SCIENCE IN DATA SCIENCE

CCD 7102: ADVANCED DATA STRUCTURES AND ALGORITHMS

DATE: JANUARY 2025 **TIME: 3 HOURS**

INSTRUCTIONS: *Answer any three questions*

QUESTION ONE (20 MARKS)

a) Consider the following code snippet implementing a data structure;

```
class ListNode:
    def __init__(self, val=0, next=None):
        self.val = val
        self.next = next

def reverseLinkedList(head):
    prev = None
    current = head
    while current:
        next_node = current.next
        current.next = prev
        prev = current
        current = next_node
    return prev
```

i. Explain each line of code and the kind of linked list it implements (5 Marks)

ii. Using clear computations, explain the time and space complexities (5 Marks)

b) Describe and compare Depth-First Search (DFS) and Breadth-First Search (BFS) algorithms; highlight the scenarios in which you would prefer one over the other (6 Marks)

c) Providing a use example in each, distinguish between an Array and a Linked List (4 Marks)

QUESTION TWO (20 MARKS)

a) Explain the concept of an AVL tree and how rotations are used to maintain balance in an AVL tree (5 marks)

b) The importance of Binary Search Trees cannot be under estimated especially on the search efficiency in data science projects. Write a Python (or Java, C++) program to implement a Binary Search Tree (BST) with the following operations;

i. Insertion of a node (8 Marks)

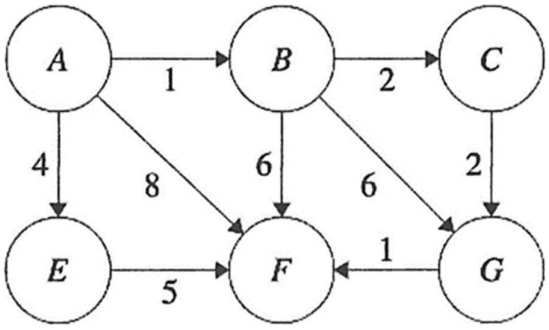
ii. Search for a node (7 Marks)

QUESTION THREE (20 MARKS)

a) Distinguish between Dijkstra's Algorithm and the Bellman-Ford algorithm (4 Marks)

b) Write appropriate Pseudo-code to implement the Dijkstra's Algorithm (6 Marks)

c) Clearly showing the table, use the Dijkstra's Algorithm to find the shortest path from in the following graph; (10 Marks)



QUESTION FOUR (20 MARKS)

a) Compare and contrast Dynamic Programming and Divide and Conquer approaches to algorithm design (4 marks)

b) Citing appropriate illustrations, outline any three scenarios in which you would apply a Dynamic Programming technique or a Divide and Conquer technique to solve a data science task (6 marks)

c) Explaining the steps, write a Python function to find the minimum spanning tree (MST) of a graph using Prim's Algorithm (10 Marks)

QUESTION FIVE (20 MARKS)

a) Consider the following unsorted list;

i. Explain the Bubble Sort Algorithm, demonstrate how it would be used to sort the above list and provide its complexity in regard to Best case, Average and Worst case scenarios (10 Marks)

ii. Using the list demonstrate how Merge Sort differs from the Bubble sort (6 Marks)

iii. Compare Quick Sort and Merge Sort in terms of time complexity, space complexity, and stability (4 Marks)