Strathmore
UNIVERSITY

SCHOOL OF COMPUTING AND ENGENEERING SCIENCES

BACHELOR OF SCIENCE IN COMPUTER NETWORKS AND CYBER SECURITY

CNS 2102: DATA STRUCTURES AND ALGORITHMS

END OF SEMESTER EXAMINATION

DATE: **29th July2022** Time: **2 Hours**

INSTRUCTIONS

1. Answer Question 1 (**Compulsory**) and any other **Two** Questions.
2. **In the calculations, show your workings for full marks.**

QUESTION 1: - COMPULSORY **30 Marks**

a. For each functions f(n) below, give an asymptotic upper bound using "big-Oh" notation. **(6 Marks)**

   i. $f(n) = 100n^3 - 7n^3 + 14n^2$

   ii. $f(n) = 100 - 100n^3 + 7n^2$

   iii. $f(n) = \log(7n^2)$

   iv. $f(n) = .001n + 100 \cdot 2n$

   v. $f(n) = n^3 (1 + 6n + 2014n^2)$

   vi. $f(n) = (\log n) \times (n + n^2)$

b. Evaluate the following. **(ab*cd/+)** where **a=3, b=5, c=8, d=2**. **(4 Marks)**

c. Explain Data abstraction? **(2 Marks)**

d. A loop invariant is some predicate (condition) that holds for every iteration in the loop. Discuss the **three** properties of a loop invariant. **(3 Marks)**

e. Distinguish between iterative algorithms and recursive algorithms with regards to Execution Approach, Time Efficiency and Usage. **(2 Marks)**

f. Depth first traversal (DFT) can be used to perform various tasks including network analysis. In full detail, describe the DFT algorithm. **(4 Marks)**

g. Describe any three differences between Arrays and Vectors **(3 Marks).**

h. Complete the bellow Java code by writing a method that can be used to add a new node with a string data type at the head position of a linked-list. Ensure you name the method **'element _insert' (4 Marks)**

```
public class Linked_Lists {
        Node head;
    class Node {
            Node next;   int data;
            public Node(int data) {this.data = data;} // Node constructor
    }
    public void element_insert(string data) {
            .... . . . . . .
        }}
```

i. Explain recursive how one can write recursive functions **(2 Marks)**

QUESTION 2 **15 Marks**

a. An algorithm can be classified as either totally or partially correct. Explain the difference between these two classifications. **(2 Marks)**

b. Use the Principle of Mathematical Induction to verify that, the n^{th} Odd number is given by, $2n - 1$. **(6 Marks)**

c. State the formal Big O definition and show that: $4x^3 + 12$ is $O(x^3)$ **(4 Marks)**

d. Consider the table below with variable k and pointer **i**

Name	Value	Memory Address
i (pointer)	000RT4	0000RQ
k	200	000RT4

Given the following sequence of commands, find the final value of integer variable **k**. *Show your working.* **(3 Marks)**

*i = *i + 100

*i = k - 150

k = *i / 50 + k

QUESTION 3 **15 Marks**

a. Fill in the table below using the relevant **Space Complexity** notations for each of the listed algorithms **(3 Marks).**

Algorithm	Space Complexity
Insertion Sort	
Merge Sort	
Bubble Sort	

b. The Java code snippet bellow shows how the core logic of a Bubble sort algorithm can be implemented to achieve a complexity of $\mathbf{O(n^2)}$. Discuss the drawbacks of this approach and suggest one way of improving the implementation. **(3 Marks)**

```
public static void sort(int[] array) {
    boolean sort_Complete = false;
    while (!sort_Complete) {
        sort_Complete = true;
        for (int i = 0; i < array.length - 1; i++) {
            if (array[i] > array[i+1]){
                swapOrder(array, i, i+1);
                sort_Complete = false;
            }
        }
    }
}
```

c. Explain why Selection Sort and Insertion Sort algorithms are considered improvements of Bubble Sort? **(2 Marks)**

d. Using relevant example, discuss the difference between an In-Place and Out-of-Place algorithm? **(4 Marks)**

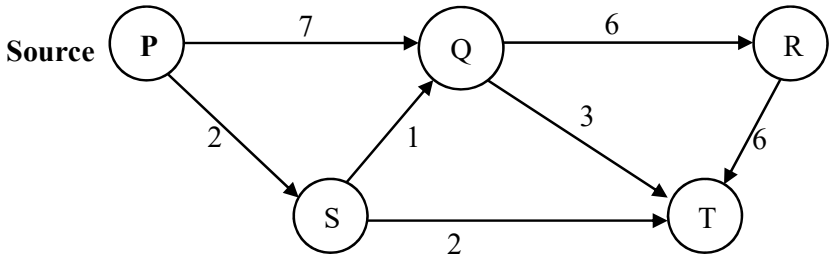
e. In a step-by-step order, list the steps involved in a Quick Sort algorithm. **(3 Marks)**

QUESTION 4 **15 Marks**

a. Describe **any two** applications of Breadth First Search. (**2 Marks)**

b. Explain the conditions for implementing Dijkstra's algorithm? **(2 Marks)**

c. Consider the non-linear structure below.

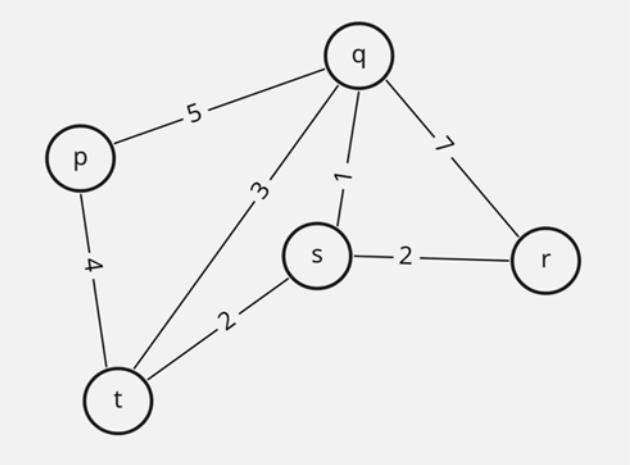


i. Apply Dijkstra's algorithm to find the shortest distances from the source to each node in the table below. **(5 Marks)**

Vertex	Shortest Distance from Source
P	
Q	
R	
S	
T	

ii. State the shortest path to get to node R, assuming node R acts as a destination. **(1 Mark)**

d. Create an adjacency matrix to represent the undirected-weighted graph given below. **(5 Marks)**



QUESTION 5 **15 Marks**

a. Describe an AVL tree? **(2 Marks)**

b. Create a BST for the number sequence. 94, 72, 110, 87, 42, 21, 51, 84, 121, 100, 106 (**3 Marks)**

c. From the BST created in question b, **add** two nodes with the values ***103*** and ***88***. Balance the resulting BST tree to form an AVL tree. **(3 Marks)**

d. Tree Traversal is a process used to visit all the nodes of a tree while using recursion. Discuss the steps involved in all three approaches used for tree traversals. **(3 Marks)**

e. An inset operation is one of the many operations that can be performed on a Binary Search Tree. In a step-by-step format, write down an algorithm that can be used to perform an element insertion in a BST. **(4 Marks).**