ITE 2142

**UNIVERSITY OF MORATUWA**
Faculty of Information Technology

Bachelor of Information Technology (BIT)
Level 2    Semester 1 Examination
**ITE 2142 – DATA STRUCTURES AND ALGORITHMS**

Time Allowed: 3 hours                                                                 September 2020

## INSTRUCTIONS TO CANDIDATES

1. This paper contains 4 questions printed on 5 pages.
2. The total marks obtainable for this examination is 100. The marks assigned for each question & sections there of are included in brackets.
3. This examination accounts for 60% of the module assessment.
4. This is a closed book examination.
5. Answer ALL questions.
6. Write the answer to each question in a new page.

## ADDITIONAL MATERIAL

None

*Continue…*

## Question 1

(i) Data structures are used to represent data in such a way that they can be accessed and processed efficiently by computer programs. Stacks and Queues are two such ways of data representation. By giving examples explain the difference between Stacks and Queues. What operations can be performed over these two data structures?

(5 marks)

(ii) Assume that it is required to model data about people who are quarantined during the COVID-19 pandemic. It is suggested to store the network details of quarantined people also so it would be easy to identity potentials who should be quarantined during the next round. Illustrate how would you design a linked list to store network details of quarantined people. Write a Java program to insert a node which represents details of a person who were interacting with a quarantined person, to the link list designed.

(5 marks)

(iii) Write pseudocode to retrieve the details of a person and his network with given id number from the linked list created in part (ii)

(3 marks)

(iv) Would it be easy to model the network details of quarantined people using an array than a linked list? By giving reasoons justify your answer.

(3 marks)

(v) Suppose that you are asked to represent a deck of cards in a card game using a doubly linked list. The cards you are using in this game is A, Q, K, J 10, 9,8,7,6. Using a diagram demonstrate how you would represent the given cards in the given order using a doubly linked list.

(4 marks)

(vi) Write a Java program to delete the card J from the doubly linked list defined above.

(5 marks)

## Question 2

(i) The two common approaches for solving repetitive work are the iterative approach and the recursive approach. Compare and contrast the iterative approach with the recursive approach using an example.

(4 marks)

(ii) The factorial of a number n is defined as shown below

$$N! = N * N\text{-}1 * N\text{-}2* ....1$$

*Continue...*

The steps to be followed for developing an algorithm to compute the factorial of a number are as follows.

```
Step 1: Declare N and F as integer variables.
Step 2: Initialize F = 1.
Step 2: Enter the value of N.
Step 3: Check whether N > 0, if not then F = 1.
Step 4: If yes, then, F = F * N.
Step 5: Decrease the value of N by 1.
Step 6: Repeat step 4 and 5 until N = 0.
```

(a) Write a pseudocode algorithm using the above steps to calculate the factorial of a number.

(5 marks)

(b) Assume N = 8 and hand trace the above pseudocode algorithm to calculate the factorial of 8. You need to give the calculations of intermediate steps.

(3 marks)

(c) Write a Java program to compute the factorial of a number using the recursive approach.

(5 marks)

(d) Calculate the best-case running time of the recursive algorithm you programmed in part (c) above.

(3 marks)

(iii)   Assume that you are given a network of locations generated by a GPS navigation system shown in Figure 1. Locations are shown in English Letters. Write the Breadth-First Search (BFS) Algorithm that you can use to traverse through the network.
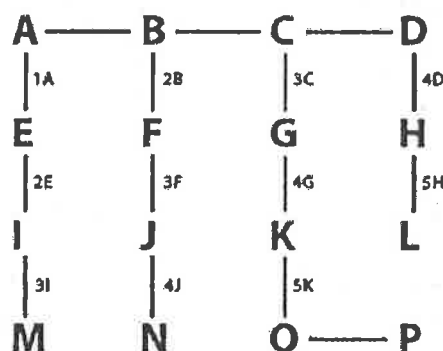


Figure 1: locations in a GPS Navigation System

(5 marks)

*Continue...*

## Question 3

(i) Assume that you have to sort a set of emails received during a given month based on the date they receive. Assume that you are given the below dates in which emails are received.

[23, 17, 30, 12 ,24, 9, 9, 6]

(a) Write a Java program for bubble sort and selection sort separately.

(6 marks)

(b) Hand trace separately to show how bubble sort and selection sort works for the above-given data set. You need to show the intermediate steps after each pass.

(4 marks)

(c) Analyze the best and worst-case run time efficiencies for the above programs written in part (a) above

(3 marks)

(ii) Assume that CPU needs to handle a given list of tasks marked with priorities. Priority values of the task is presented as shown below.

(T1,12), (T2, 1) , (T3, 3), (T4,11), (T5,4) , (T6,5), (T7,6), (T8, 9), (T9,10), (T10,7), (T11,8), (T12,2)

(a) It is suggested to develop a quick sort algorithm to order the task list and to identify task which has the highest priority. Consider the following steps used to divide the above list of values into two arrays.

```
Step 1 - Choose the highest index value as pivot
Step 2 - Take two variables to point left and right of
         the list excluding pivot
Step 3 - left points to the low index
Step 4 - right points to the high
Step 5 - while value at left is less than pivot move
         right
Step 6 - while value at the right is greater than pivot
         Move left
Step 7 - if both step 5 and step 6 does not match swap
         left and right
Step 8 - if left ≥ right, the point where they met is new
         pivot
```

Write a Java program by considering the above steps to divide the array of task priorities into two sub-arrays.

(5 marks)

(b). Define a recursive quicksort algorithm in Java using the program defined in part to order the task.

(5 marks)

(c) Hand trace the execution of the quicksort with the given values and identify the task with the highest priority.

(2 marks)

*Continue…*

## Question 4

(i) Suppose that following set of numbers are to be sorted with merge sort algorithm.
12,4,5, 6, 8, 8, 13, 90

(a) Write merge sort algorithm in Java based on the steps given below.

```
Step 1 - if it is only one element in the list, it is already
         sorted, return.
Step 2 - divide the list recursively into two halves until it
         can no more be divided.
Step 3 - merge the smaller lists into new list in sorted order.
```
(5 marks)

(b) Hand trace execution of merge sort algorithm with the given data set.

(3 marks)

(c) Analyze the performance of the merge sort algorithm

(2 marks)

(ii) Create a binary search tree with the following set of values taking the first value as the root.

150, 110, 140, 125, 175, 170, 235, 537, 690, 960

(3 marks)

(a) Write a recursive pseudocode to insert a given value into a binary search tree and modify the binary search tree drawn in part(i) to insert value 165.

(3 marks)

(b) Write a Java program to generate a pre-order traversal algorithm

(3 marks)

(iii)

(a) Insert the objects with key values 15, 17, 8, 23, 3, 3 and 5, respectively, into an initially empty hashtable of size 7 with the hash function $h(x) = x \mod 7$.

(2 marks)

(b) Use open addressing with linear probing to insert the objects in the given order.

(2 marks)

(c) Use open addressing with quadratic probing to insert the objects in the given order.

(2 marks)

### END OF PAPER