Midterm **Comp Sci 2C03** - *Data structures and Algorithms* *Fall 2021*

Name _____ Student No._____

- For your exam you are ONLY allowed to refer to the lecture notes, text book, tutorials and assignments.
- Surfing the internet for ideas and answers is not allowed.
- **Submit your exam on Avenue as a single PDF file named firstname_lastname.pdf.**
- Clearly write your full name and student number on each sheet.

Time allotted: 2 hours **Total Marks: 30**
(for the test and uploading solution PDF on Avenue)

Multiple choice questions [7 marks]

Circle your answer. Each question has just one correct answer. Therefore multiple selections will not get a mark.

1. **The function** $T(n) = n \log n + n^2 + 2n + 3$ **is in**
   (a) $\Omega(n^3)$
   (b) $\Theta(n^2)$
   (c) $O(n \log n)$
   (d) None of the above.

2. **Suppose all the connected components of a graph are provided. The maximum number of queries on them require you to identify in which component does a given node** x **belong to. In this scenario, which of the below approaches would perform the best?**
   (a) Quick-find + union
   (b) Quick-union + find
   (c) Weight Quick-union + find
   (d) Weight Quick-union + find with path compression

3. **Statement 1: Shell sort is a stable sorting algorithm.**
   Statement 2: Shell sort is an in-place sorting algorithm.

   (a) Both statements are true

   (b) Statement 2 is true but statement 1 is false

   (c) Statement 2 is false but statement 1 is true

   (d) Both statements are false

4. **Which of the following sorting algorithms is generally used along with quick-sort to sort the sub arrays?**

   (a) Selection sort

   (b) Shell sort

   (c) Insertion sort

   (d) Merge sort

5. **A full binary tree has 32 leaf nodes. What is the height of this tree?**

   (a) 32

   (b) 5

   (c) 6

   (d) 2

6. **Suppose that a certain BST has keys that are integers between 1 and 10, and we search for 7. Which sequence below cannot be the sequence of keys examined?**

   (a) 10, 9, 8, 7

   (b) 4, 10, 8, 7

   (c) 2, 5, 3, 8, 4, 7

   (d) 1, 10, 2, 9, 3, 8, 4, 7

7. **Choose the sequence of nodes visited/printed in a preorder traversal of the tree give in Figure 1.**

   (a) A, E, H, K, M, O, P, Q, T, V

   (b) M, K, E, A, H, Q, O, T, P, V

   (c) M , K , E, A, H, Q, O, P, T, V

   (d) M K Q E, A, H, O, T, P, V

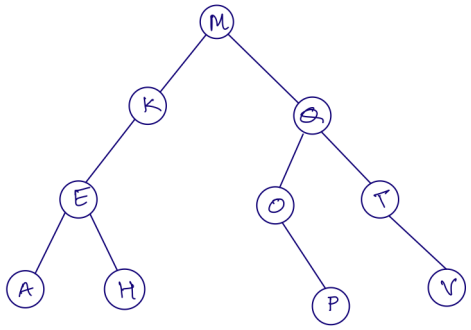

Figure 1: Binary Tree for MCQ 7

Provide detailed answers to the 5 questions below

1. Let $L = L_L L_R$ be a doubly linked list such that L_L is the first half of L and L_R is the right half of L. Give a double linked list implementation of ROTATE_HALF algorithm that does the following: Takes the list $L = L_L L_R$ as the input and outputs a new list $L' = L_R L_L$. You may assume that you have all the data values and operations supporting a double linked list L such as $L.head; L.tail$, and all the node (x) values and operations such as $x.next; x.prev; x.value$. [5 marks]

2. Assume Weighted Quick Union model and the following id[] array:

i	0	1	2	3	4	5	6	7	8	9
$id[]$	0	0	0	3	3	6	7	7	9	9

   (a) Draw the forest represented by the above table. [2 marks]

   (b) Execute Union(3,5) and draw the resulting forest/tree. [2 marks]

3. (a) Suppose that top-down mergesort algorithm is modified to skip the call on merge() whenever $a[mid] \leq a[mid+1]$. Then give the number of compares on an input array consisting of distinct elements and sorted order in ascending order. Explain your answer. [3 marks]

   (b) Is an array that is sorted in decreasing order a max heap. Explain your answer. [2 marks]

4. Consider the BST given in Figure 2.

   a. Give the sequence of nodes visited to compute the floor(N) and ceiling(I) operations in the BST given in Figure 2. [1 mark]

   b. Give the sequence of nodes visited to compute the minimum and maximum operations in the BST given in Figure 2. [1 mark]

c. What is the `rank` of the node Q in the BST given in Figure 2. [1 mark]

d. Draw the resulting tree after deleting 'I' from it, using Hibbard's deletion. [1 mark]

e. Draw the resulting tree when the key D is inserted into the tree obtained after (d). [1 mark]

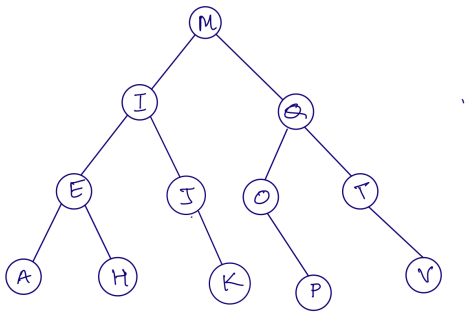

Figure 2: BST for Q4

5. Draw the left leaning red-black tree (LLRBT) that results when you insert the keys **C O M P U T E** in that order into an initially empty LLRBT. Show the resulting LLRBT after every insertion.[4 marks]