Final Exam **Comp Sci 2C03** - *Data structures and Algorithms* *Winter 2021*

Name _____ Student No._____

For your exam you are ONLY allowed to refer to the lecture notes, text book, and tutorials.

Time allotted: 3 hours (write and submit PDF) **Total Marks: 33**

Multiple choice questions [10 marks]

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

1. Suppose `x` is a linked-list node and not the last node/tail in the list. What is the effect of the following code fragment: `x.prev.next = x.next`?

   (a) Deletes from the list the node immediately following `x`.

   (b) Deletes from the list the node immediately preceding `x`.

   (c) Deletes from the list the node `x`.

   (d) None of the above.

2. Insertion sort is the sorting algorithm of choice for small (< 10) arrays.

   (a) True

   (b) False

3. Suppose that your application will have a huge number of find the maximum operations, but a relatively small number of insert and remove the maximum operations. Which priority-queue implementation do you think would be most effective:

   (a) heap

   (b) unordered array

   (c) ordered array

   (d) None of the above

4. What is the sequence of nodes printed during a preorder traversal of the tree given in Figure 1?

   (a) A C E H I N R S

   (b) E A S C I H R N

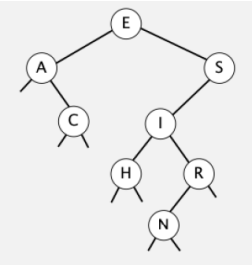

Figure 1: Trees for multiple choice Question 4.

(c) E A C S I H R N

(d) S E A R C H I N

5. Which insertion order for the keys S E A R C H I T leads to a 2-3 tree of height 1.

   (a) A I R E H C T S

   (b) A E T C H S R I

   (c) A E T C R S H I

   (d) None of the above

6. Hashing/hash table is not suited for ordered symbol-table operations.

   (a) True

   (b) False

7. An edge weight undirected graph with all distinct weights has a unique MST.

   (a) True

   (b) False

8. Adding a constant to every edge weight does not change the solution to the single-source shortest-paths problem.

   (a) True

   (b) False

9. To sort one million 32-bit integers. Which sorting method is the best to use?

   (a) Insertion sort

   (b) Meargesort

   (c) Quicksort

   (d) LSD string sort

10. Consider the `text = c c c c c c c c c c`, and the pattern `pattern = c c c`. Let BMC = no.of comparisons done by Boyer-Moore (with only bad character rule), RKC= no.of comparisons done by Rabin-Karp, and KMPC = no.of comparisons done by KMP. Which of the below statement is correct?

    (a) KMP > BMC and KMP < RKC

    (b) KMP < BMC and KMP > RKC

    (c) KMP < BMC and KMP < RKC

    (d) KMP > BMC and KMP > RKC

Provide detailed answers to the 6 questions below

1. (a) Using ONLY the definition of $O(f(n))$ prove that for $T(n) = n^2 \log_2 n + 2n + 1$, $T(n) \in \Theta(n^2 \log_2 n)$. Your proofs using Limits will not get a mark. [2 marks]

    (b) Using ONLY the definition of $\Theta(f(n))$ prove that for $T(n) = n^3 + 5n + 10$, $T(n) \notin \Theta(n^2)$. Your proofs using Limits will not get a mark. [2 marks]

2. About how many compares will Quick.sort() make when sorting an array of N items with just two distinct keys. Your solution in big-Oh notation will suffice? [3 marks]

3. Compute the MST of the undirected edge-weighted graph shown in the Figure 2 using Kruskal's Algorithm. You solution must contain the order in which edges are added to the MST. [3 marks]

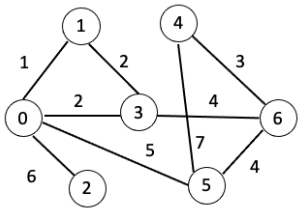

Figure 2: Undirected weighted edge graph

4. How can we find shortest paths in undirected positive edge-weighted graphs? Just provide the outline for your solution. [3 marks]

5. Let w be a nonempty string of length n. An integer p such that $w[i] = w[i + p]$ for all $i = 0, 1, ..., n - p - 1$. is called a **period** of w.

    (a) What is the relationship between a period p and a border b of a string of length n (just the formula with suffice). [2 marks]

(b) How would you use the border array (discussed on slides# 7, 8 of C5P3.pdf) of a string of length n to compute the minimum period of the input string w. The minimum period of a string is its smallest period. For example, the minimum period of the string ABCABCABCABCAB is 3. [2 marks]

6. Given the input string, `text = a b a a b a a c b c b a a a b`. You may assume that the input string is given in 7-bit ASCII.

   (a) Give the encoded string obtained by applying Huffman encoding. You solution must contain the prefix-free code trie created by the Huffman encoding. [3 marks]

   (b) Give the encoded string obtained by applying the LZW compression algorithm. You may assume that the output is in 8-bit codewords in hexadecimal. Your solution must contain the symbol table and the entries added to it during the encoding process. [3 marks]