ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION WINTER SEMESTER, 2022-2023

DURATION: 3 HOURS FULL MARKS: 150

CSE 4303: Data Structures

Programmable calculators are not allowed. Do not write anything on the question paper.
Answer **all 6 (six)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. Consider the directed-weighted graph in Figure 1 to answer the following questions:

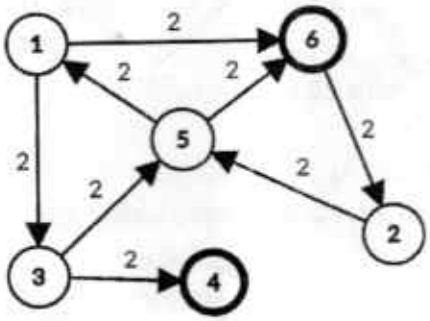

Figure 1: Directed weighted graph for Question 1

a) Show the adjacency list representation of the graph. 5 (CO1) (PO1)

b) Find the shortest path and distance from node 6 to node 4 using Breadth-First-Search algorithm. 10 (CO2) (PO1)

c) Find the strongly-connected component set of nodes from the graph. 6 (CO2) (PO1)

d) Define the following terms: 4 (CO1) (PO1)
   i. Isolated vertex
   ii. Pendant vertex
   iii. Reachability
   iv. Self-Loop

2. a) An algorithm $f(n)$ takes 1 second to run with problem size $= 8$. Find the approximate runtime for the problem size = 16 with the following complexities: 5 (CO3) (PO1)
   i. $f(n) = O(n)$
   ii. $f(n) = O(log_2(n))$
   iii. $f(n) = O(n^2)$
   iv. $f(n) = O(n^3)$
   v. $f(n) = O(2^n)$

b) Draw the classification hierarchy of Data Structures. 5 (CO1) (PO1)

c) Check if the following parenthesis are balanced or not with a help of an approximate data structure. Show the scanned parenthesis and the state of the stack in two columns. 15 (CO2) (PO1)

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3. a) Using appropriate diagram(s), show the two cases of increasing capacity of a circular array implementation based queue. 5 + 5 (CO1) (PO1)

b) Consider the following sorted array of integers: 4 (CO2) (PO1)

{ 2, 6, 10, 15, 16, 29, 30, 35, 39, 44, 45, 48, 58, 73, 80, 96 }

Using binary search, find the index of value 30 in the given array. You need to show each step.

c) Explain lexicographical priority with 2 examples. 3 (CO2) (PO1)

d) i. Analyze the run-time complexity of the binary search using the answer of Question 3.b) as an example. 4 + 4 (CO3) (PO2)

ii. Analyze the space complexity if we want to store any binary tree in an array using the breadth-first traversal order where the children of the i^{th} node reside at $(2 \times i)$ and $(2 \times i + 1)$ indices.

4. a) Draw five(5) different binary search tree configuration using the following values: 5 (CO1) (PO1)

{ 11, 13, 17, 19 }

b) Write the steps of finding the 2^{nd} largest value of a Binary Search Tree. 5 (CO2) (PO1)

c) Consider the following sequence of integers: 8 + 4 (CO2) (PO1)

{ 11, 82, 83, 5, 7, 3, 15, 14 }

i. Build an AVL tree by inserting the given data sequentially. Show necessary rotations steps for re-balancing after each insertion. Show balance factor on each of the nodes.

ii. Delete the values 5 and 3 sequentially from the AVL tree built in 4.c)i.

d) Analyze the space-time complexity of AVL tree Insertion and Deletion 3 (CO3) (PO2)

5. a) A 0-indexed array of integer numbers is as follows: 5 + 3 + 2 (CO2) (PO1)

{ 17, 60, 85, 40, 81, 24, 71, 82, 6, 79 }

i. Build a range-sum Fenwick tree with the given integer numbers. Each entry of the tree-array should show the node value and range it covers.

ii. Calculate a range sum query on range [3, 7].

iii. Update the value of index 5 with 50 by showing the changes in the tree-array.

b) A 0-indexed array of integer numbers is as follows: 5 +

$$\{23, 89, 47, 30, 32, 46, 79, 98, 27, 23\}$$

3 + 2 (CO2) (PO1)

i. Build a range-sum segment tree with the given integer numbers. Each node should show the node value and range it covers.

ii. Calculate a range sum query on range [3, 7] by showing the sub-range values in the segment tree nodes.

iii. Update the value of index 5 with 50 by showing the changes in the segment tree nodes.

c) Explain the following terms: 5 × 1 (CO1) (PO1)

i. Hash Collision

ii. Chaining

iii. Linear Probing

iv. Quadratic Probing

v. Double Hashing

6. a) A set of strings is as follows: 6 +

abcde, abcef, acde, bcde, abcfg, abc, abcdf

6 + 3 (CO2) (PO1)

i. Draw a trie tree to efficiently find the number of string with same prefix.

ii. Write the steps to delete the string *bcde* and re-draw the trie tree.

iii. Write the steps of finding the number of string with prefix *abc* from the trie tree from 6.a)ii.

b) Assume you are searching for the Pattern:"ssfu" in the Text:"successful". 6 + 4 (CO2) (PO1)

Table 1: Hash value of $b^i \bmod m$ for Question 6.b)

i :	0	1	2	3	4	5	6	7	8	9
hash :	1	37	1369	1292	2240	3143	2381	766	1763	682

i. Calculate the hash value of the Text and Pattern with base $b = 37$ and modulo $m = 3797$

ii. Determine the index of the first occurrence of the Pattern in the Text using the hash calculated in Question 6.b)i.