



ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION
DURATION: 3 HOURS

WINTER SEMESTER, 2022-2023
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.

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

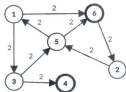


Figure 1: Directed weighted graph for Question 1

- | | |
|--|----------------------|
| 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:
i. Isolated vertex
ii. Pendant vertex
iii. Reachability
iv. Self-Loop | 4
(CO1)
(PO1) |
| 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:
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. $f(n) = O(2^n)$ | 5
(CO3)
(PO1) |

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)
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: $\{ 2, 6, 10, 15, 16, 29, 30, 35, 39, 44, 45, 48, 58, 73, 80, 96 \}$ Using binary search, find the index of value 30 in the given array. You need to show each step.	4 (CO2) (PO1)
	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. 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 + 4 (CO3) (PO2)
4.	a) Draw five(5) different binary search tree configuration using the following values: $\{ 11, 13, 17, 19 \}$	5 (CO1) (PO1)
	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: $\{ 11, 82, 83, 5, 7, 3, 15, 14 \}$ 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.	8 + 4 (CO2) (PO1)
	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: $\{ 17, 60, 85, 40, 81, 24, 71, 82, 6, 79 \}$ 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.	5 + 3 + 2 (CO2) (PO1)

- b) A 0-indexed array of integer numbers is as follows: 5 +
 { 23, 89, 47, 30, 32, 46, 79, 98, 27, 23 } 3 + 2
 i. Build a range-sum segment tree with the given integer numbers. Each node should show the node value and range it covers. (CO2)
 ii. Calculate a range sum query on range [3, 7] by showing the sub-range values in the segment tree nodes. (PO1)
 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
 i. Hash Collision (CO1)
 ii. Chaining (PO1)
 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
 i. Draw a trie tree to efficiently find the number of string with same prefix. (CO2)
 ii. Write the steps to delete the string *bcde* and re-draw the trie tree. (PO1)
 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>i</i> :	0	1	2	3	4	5	6	7	8	9
<i>hash</i> :	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.