

INDIAN STATISTICAL INSTITUTE

BACKPAPER EXAMINATION M.TECH(CrS) I YEAR

PROGRAMMING AND DATA STRUCTURES

Date: 30.12.2025 Maximum marks: 100 Duration: 3 hours.

The paper contains 110 marks. Answer as much as you can.

1. Give the tightest possible upper bound for the worst case running time for each of the following operations in terms of n . Give a very short explanation for your answer.
 - (a) Pushing a value onto a stack containing n values, implemented as a linked list.
 - (b) Finding the maximum value in a binary min heap of size n .
 - (c) Finding and deleting the minimum value in a binary search tree of size n .
 - (d) Finding and deleting the minimum value in a balanced binary search tree of size n .
 - (e) Given an AVL tree containing n positive integers, print out all the even values contained in the tree in descending order.

[5 × 3 = 15]

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2.
 - (a) Suppose we have a pointer to a node in a singly linked list that is guaranteed not to be the last node in the list. We do not have pointers to any other nodes (except by following links). Describe an $O(1)$ algorithm that removes the value stored in such a node from the linked list, maintaining the integrity of the linked list.
 - (b) Suppose we want a data structure supporting the operations **Insert** and **FindMin**. Give the most efficient implementation of such a data structure both in terms of running time and space.
 - (c) Let t be the root of a standard binary tree with the usual fields **data**, **left** and **right**. Write a procedure to find the height of the tree, given t .
 - (d) Suppose that we first insert an element x into a binary search tree that does not already contain x . Suppose that we then immediately delete x from the tree. Will the new tree be identical to the original one? If yes give the reason in no more than 3 sentences. If no give a counter-example. Draw pictures if necessary.
 - (e) Suppose we have a binary heap H and two values v_1 and v_2 , such that all values are distinct. Let H_{12} be the heap you get if you insert v_1 and then v_2 into H , and H_{21} be the heap you get if you insert v_2 and then v_1 into H . Give an example of H , v_1 and v_2 such that $H_{12} \neq H_{21}$. No justification needed, just draw the heaps H , H_{12} and H_{21} .

[5 × 5 = 25]

7. We have to implement a phone book using a hash table which would have the facility of looking up a phone number given a name.
- (a) Design a hash function for the given purpose. Assume that names are strings over the alphabet which contains only uppercase English letters and blank. Also assume that there is only a single phone number associated with any name.
 - (b) Compute the collision probability of the hash function you designed.
 - (c) Assuming you use chaining, what would be the expected time required to lookup a phone number given a name.

[5 + 5 + 5 = 10]