NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA
■ **Data Structures and Algorithms** ■ **CS-2005**
■ **Autumn–2023, End Sem** ■ **50 Marks** ■ **2 Pages**
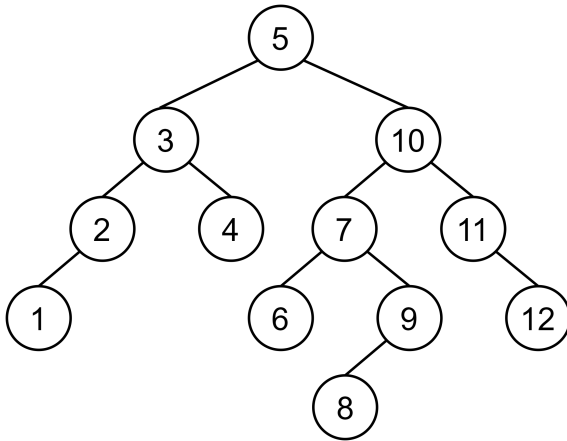■ **Time: 3hrs** ■ **Answer ALL Questions**

DO NOT use pencil for answering. Mere answers without proper justification would not fetch any mark.
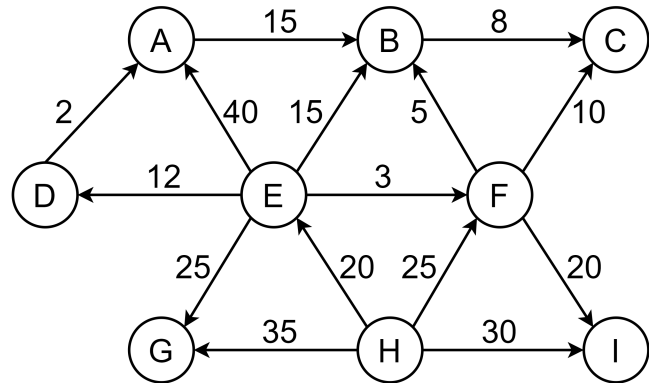
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1. (a) What is the minimum and maximum number of nodes at depth d in a complete binary tree which is a 2-tree? [2]

   (b) You are given a binary min heap of height 6. What is the minimum and maximum number of comparisons we might have to do when doing a delete min operation? [2]

   (c) Differentiate between a connected and a complete graph. Give examples of each. [2]

   (d) Construct a 5-way search tree with elements: $28, 41, 12, 75, 4, 35, 65, 32, 85, 31$, and 33. [2]

   (e) What do you mean by *relaxing* an edge in Dijkstra's Shortest Path Algorithm? Briefly explain with an example. [2]

2. (a) Array and linked list are linear data structures. Graph can be represented using adjacency matrix (a 2-D array) or adjacency lists (set of linked lists). Justify how then graph is a non-linear data structure. [2]

   (b) Given a linear array of elements: $10, 15, 17, 20, 29$. Your task is to construct a two-way linked list from the given linear array. Each node of the linked list corresponds to an element in the array. The information that you must put in each node are: the element from the array, its position in the array, a character 'E' or 'O' based on the element is even or odd. Define a structure in C language to represent nodes in the two-way list. Sketch the two-way list for the given array. What is the total storage requirement for the two-way list, considering pointers to be of 8 bytes? Size of int and char are 4 bytes and 1 byte respectively. [3]

   (c) Consider a bank has a single window service facility. The customers stand in a queue for the service. In a regular interval of x minutes, a new customer arrives. The service time of each customer is y minutes and $y \geq x$. Derive the expression for average waiting time of the customers in the queue, considering the bank served total N customers and the queue never overflows. [5]

3. (a) Given an array of elements: $[30, 40, 5, 80, 2, 35, 60, 32]$. Sort these elements in descending order using Bubble sort. Calculate the number of comparisons and number of swap operations. [5]

   (b) What is a Sparse Matrix? Give an example of 5×5 lower-triangular matrix across auxiliary diagonal. [1]
   Consider the following representations of a Sparse Matrix of order $m \times n$. [4]

   - Row-Lists representation (Single chain per row)
   - Column-Lists representation (Single chain per column)

   Find the worst-case time complexity of the following operations in each of the above representations.

   - Set the first non-zero element in k^{th} column to zero.
   - Set all nonzero elements of kth row to zero
   - Set the first zero element in k^{th} column to non-zero value 5.
   - Set all zero elements of kth row to non-zero value 5.

4. (a) The pre-order and in-order traversal sequence of a binary tree are given as follows. Construct the tree. Show each step clearly. After the construction, write the post-order traversal sequence of the tree. [5]
   Pre-order: L, B, D, G, H, J, F, E, K, C, A, I
   In-order: H, G, J, D, B, E, F, L, A, C, I, K

(b) Consider the following BST in Fig. (1a).

    i. Draw the resulting BST, after deleting the root node. Make sure that the subtree rooted at 10 remains unaltered. [1]

    ii. Convert the resulting BST to an AVL by applying appropriate rotations. [4]

(a) Tree for Q.4b   (b) A digraph G for Q. 5

Figure 1

5. (a) Consider the digraph G given in Fig. (1b). Represent the digraph using adjacency matrix and adjacency lists. Assuming integers are of 4 bytes, characters are of 1 byte, and pointers are of 8 bytes, calculated the amount of storage requirement in each representation. [5]

(b) Consider the digraph G given in Fig. (1b). Find the minimum spanning tree of G using Krushkal's algorithm. Depict the MST in conventional hierarchical tree representation (like in Fig. 1b). What are the nodes in level-2 of the MST? Show each step clearly. [5]