Experiment-2.1.1: Same Tree

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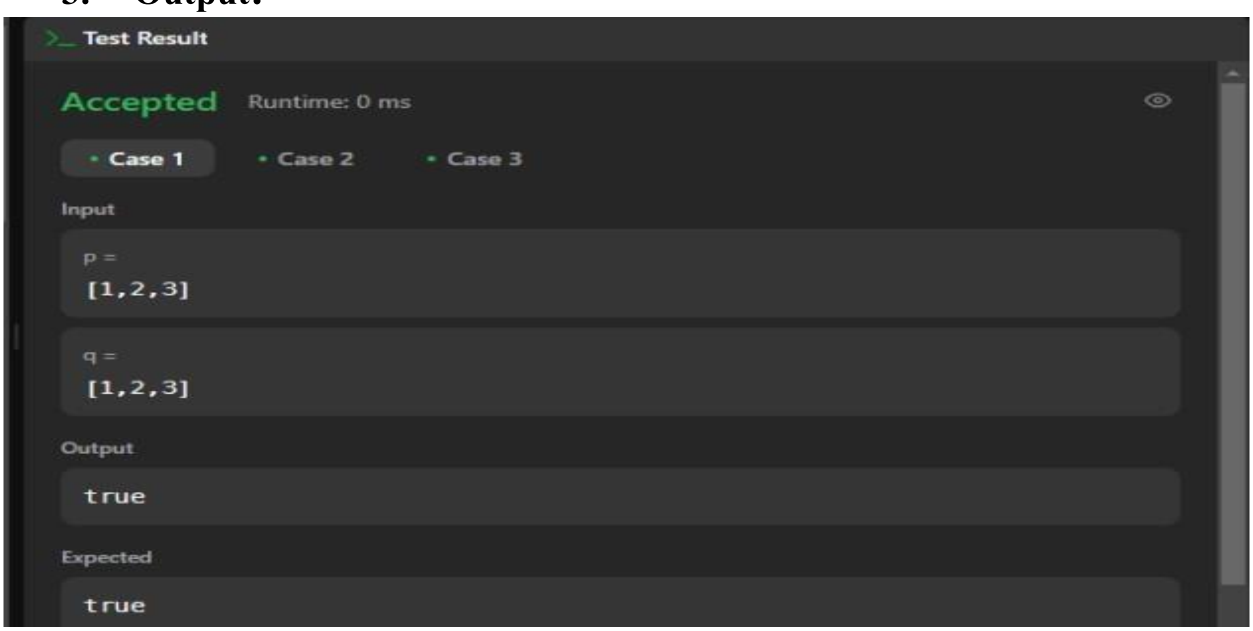
1. **Aim:** Given the roots of two binary trees p and q, write a function to check if they are the same or not. Two binary trees are considered the same if they are structurally identical, and the nodes have the same value.

2. **Implementation/Code:**

```
class Solution {
   public boolean isSameTree(TreeNode p, TreeNode q) {
      if (p == null && q == null) return true;
if (p == null || q == null) return false;         if
(p.val != q.val) return false;
      return isSameTree(p.left, q.left) && isSameTree(p.right, q.right);
   }
}
```

3. **Output:**



Leetcode Link: https://leetcode.com/problems/same-tree/

Experiment-2.1.2 Symmetric Tree

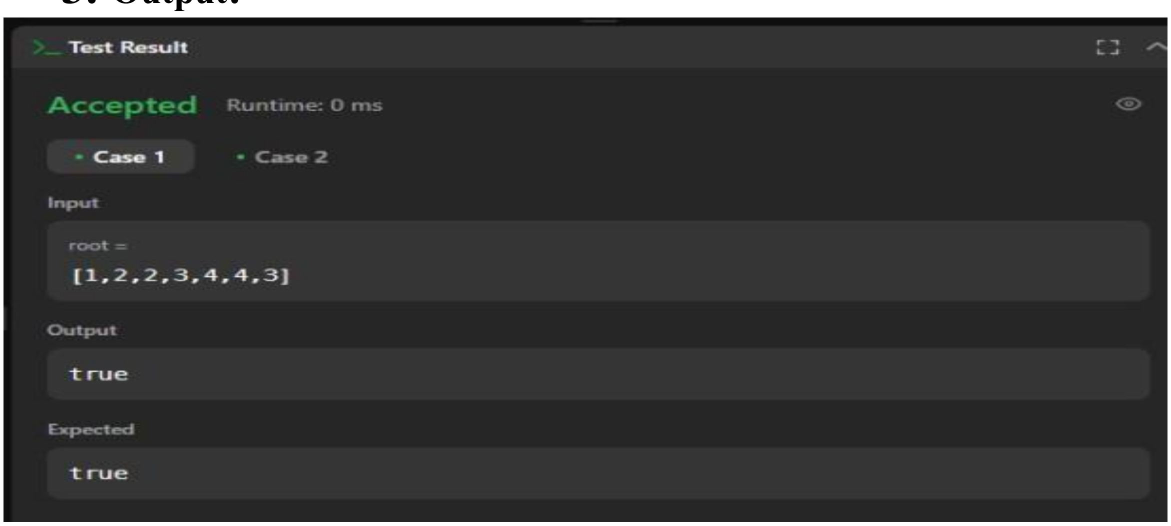
1. **Aim:** Given the root of a binary tree, check whether it is a mirror of itself (i.e., symmetric around its center).

2. **Implementation/Code:**

```
class Solution {
   public boolean isSymmetric(TreeNode root) {
      if (root == null) return true;
return isMirror(root.left, root.right);
   }

   private boolean isMirror(TreeNode t1, TreeNode t2) {
      if (t1 == null && t2 == null) return true;
if (t1 == null || t2 == null) return false;
      return (t1.val == t2.val) && isMirror(t1.left, t2.right) && isMirror(t1.right, t2.left);
   }
}
```

3. **Output:**



Leetcode Link: https://leetcode.com/problems/symmetric-tree/

Experiment-2.1.3 Balanced Binary Tree

1. **Aim:** Given a binary tree, determine if it is height-balanced. A binary tree is height-balanced if the difference between the heights of the left and right subtrees of any node is no more than 1.
2. **Implementation/Code:**

```
class Solution {
   public boolean isBalanced(TreeNode root) {
      return height(root) != -1;
   }

   private int height(TreeNode node) {
if (node == null) return 0;

      int leftHeight = height(node.left);
if (leftHeight == -1) return -1;

      int rightHeight = height(node.right);
      if (rightHeight == -1) return -1;

      if (Math.abs(leftHeight - rightHeight) > 1) return -1;

      return Math.max(leftHeight, rightHeight) + 1;
   }
      }
```

Leetcode link: https://leetcode.com/problems/balanced-binary-tree/

3. **Output:**

Experiment-2.1.4 Path Sum

1. Aim: Given the root of a binary tree and an integer targetSum, return true if the tree has a root-to-leaf path such that adding up all the values along the path equals targetSum. **2. Implementation/Code:**

```
class Solution {
   public int countNodes(TreeNode root) {
      if (root == null) return 0;

      int leftDepth = getDepth(root.left);
      int rightDepth = getDepth(root.right);

      if (leftDepth == rightDepth) {
         return (1 << leftDepth) + countNodes(root.right);
      } else {
         return (1 << rightDepth) + countNodes(root.left);
      }
   }

   private int getDepth(TreeNode node) {
int depth = 0;         while (node != null) {
depth++;           node = node.left;
      }
      return depth;
   }
}
```

Leetcode link: https://leetcode.com/problems/count-complete-tree-nodes/

3. Output:

Experiment-2.1.5 **<u>Delete Node in a BST</u>**

1. **Aim:** Given the root of a BST and a key, delete the node with the given key in the BST. 2. **Implementation/Code:**

```
class Solution {
   public TreeNode deleteNode(TreeNode root, int key) {
if (root == null) return null;

      if (key < root.val) {
         root.left = deleteNode(root.left, key);
      } else if (key > root.val) {
         root.right = deleteNode(root.right, key);
      } else {            if (root.left == null)
return root.right;            if (root.right ==
null) return root.left;

         TreeNode minNode = getMin(root.right);
         root.val = minNode.val;
         root.right = deleteNode(root.right, minNode.val);
```

```
        }
        return root;
    }

    private TreeNode getMin(TreeNode node) {
        while (node.left != null) {
            node = node.left;
        }
        return node;
    }
}
```

3. Output:

Leetcode Link: https://leetcode.com/problems/delete-node-in-a-bst/

Experiment-2.1.6 Count Complete Tree Nodes

1. **Aim:** Given the root of a binary tree, check whether it is a mirror of itself (i.e., symmetric around its center).

2. **Implementation/Code:**

```
class Solution {
    public int countNodes(TreeNode root) {
        if (root == null) return 0;
```

```
        int leftDepth = getDepth(root.left);
int rightDepth = getDepth(root.right);

        if (leftDepth == rightDepth) {
            return (1 << leftDepth) + countNodes(root.right);
        } else {
            return (1 << rightDepth) + countNodes(root.left);
        }
    }

    private int getDepth(TreeNode node) {
int depth = 0;        while (node != null) {
depth++;            node = node.left;
        }
        return depth;
    }
}
```

Leetcode Link: https://leetcode.com/problems/count-complete-tree-nodes/

3. Output:

Experiment-2.1.7 **Diameter of Binary Tree**

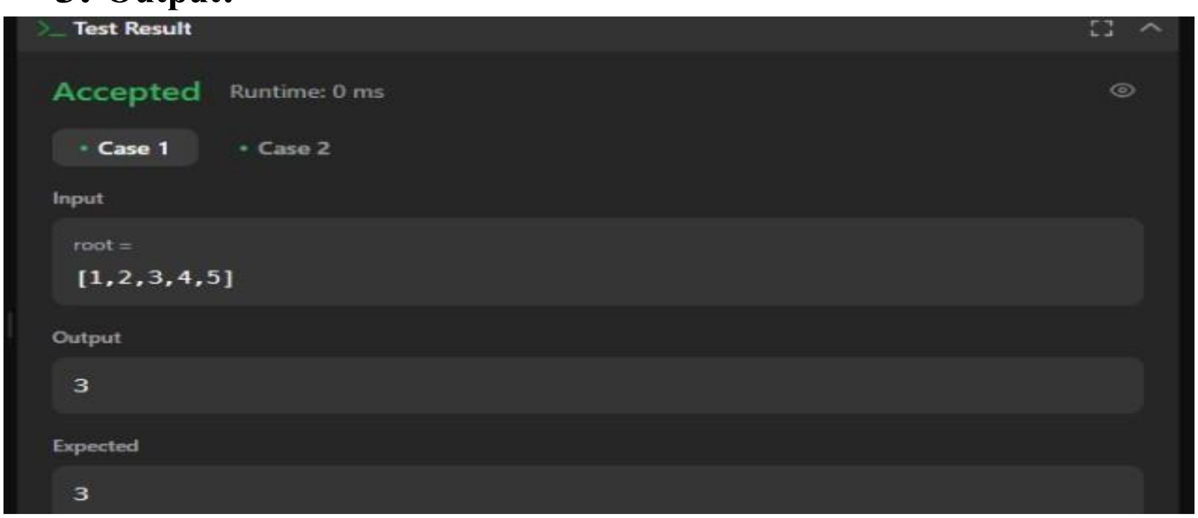
1. Aim: Given the root of a binary tree, return the length of the diameter of the tree. The diameter of a binary tree is the length of the longest path between any two nodes in a tree. **2. Implementation/Code:**

```
class Solution {
   private int diameter = 0;

   public int diameterOfBinaryTree(TreeNode root) {
depth(root);
       return diameter;
   }

   private int depth(TreeNode node) {
if (node == null) return 0;         int
leftDepth = depth(node.left);         int
rightDepth = depth(node.right);
       diameter = Math.max(diameter, leftDepth + rightDepth);
return Math.max(leftDepth, rightDepth) + 1;
```

3. Output:



Leetcode Link: https://leetcode.com/problems/diameter-of-binary-tree/

Here are the time and space complexities for each problem:

Same Tree

- **Time Complexity:** O(min(N, M)) (where N and M are the number of nodes in each tree)
- **Space Complexity:** O(min(H_1, H_2)) (recursive stack, where H is the height of the trees)

Symmetric Tree

- **Time Complexity:** O(N) (each node is visited once)
- **Space Complexity:** O(H) (recursive stack for DFS, where H is the height of the tree)
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Balanced Binary Tree

- **Time Complexity:** O(N) (each node is visited once)
- **Space Complexity:** O(H) (recursive stack depth)

Path Sum

- **Time Complexity:** O(N) (traverse all nodes in the worst case)
- **Space Complexity:** O(H) (recursive call stack)

Count Complete Tree Nodes

- **Time Complexity:** O($\log^2$ N) (binary search approach)
- **Space Complexity:** O(log N) (recursive stack in worst case)

Delete Node in a BST

- **Time Complexity:** O(H) = O(log N) for balanced BST, O(N) for skewed BST
- **Space Complexity:** O(H) (recursive stack)

Diameter of a Binary Tree

- **Time Complexity:** O(N) (each node is visited once)
- **Space Complexity:** O(H) (recursive stack)

Learning Outcomes:

- **Same Tree** – Learn to compare two binary trees for identical structure and values.
- **Symmetric Tree** – Understand how to check if a binary tree is a mirror of itself using recursion.
- **Balanced Binary Tree** – Determine if a binary tree is height-balanced by computing subtree heights efficiently.
- **Path Sum** – Verify if a root-to-leaf path exists with a given sum using recursive traversal.
- **Count Complete Tree Nodes** – Optimize node counting in a complete binary tree using binary search and height calculations.
- **Delete Node in a BST** – Implement node deletion in a BST while preserving its structure.
- **Diameter of a Binary Tree** – Compute the longest path between any two nodes, considering subtree heights.