Experiment - 6

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Section: **IOT** 703/A
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Subject: AP LAB - 2
Subject Code: 22ITP-351

1. Aim:

Problem 1.2.1: Maximum Depth of Binary Tree

Problem Statement: Maximum Depth of Binary Tree Find the maximum depth of a binary tree, defined as the longest root to-leaf path. Use a recursive depth-first search (DFS) or iterative breadth-first search (BFS). The DFS approach runs in O(n) time and O(h) space, where h is the tree height. Edge cases include an empty tree (depth 0) and a skewed tree (depth n).

2. Objectives:

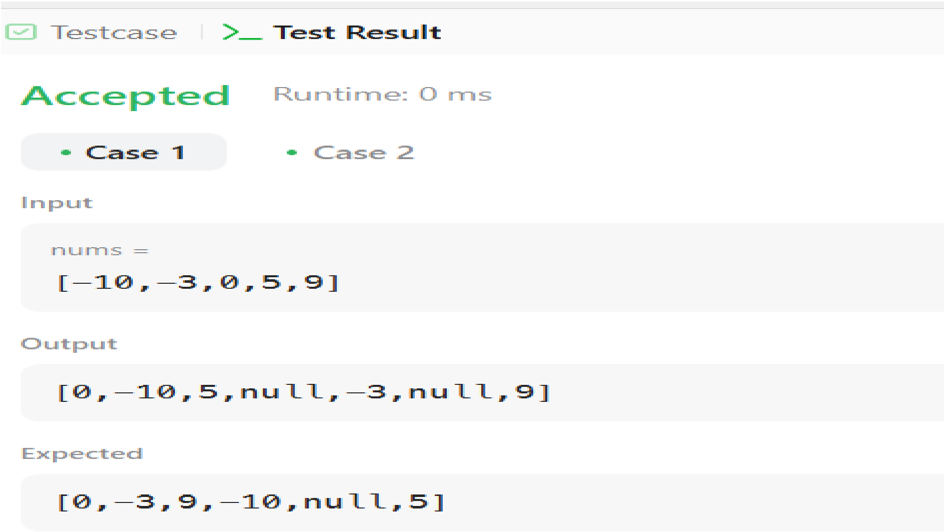
- Implement efficient algorithms for array and string manipulation.
- Develop skills in using data structures like array, stacks and queues.
- Learn and apply brute force and greedy techniques to optimize solutions.

3. Implementation of Code:

```
class Solution {
public:
    int maxDepth(TreeNode* root) {
        if(root==nullptr){
            return 0;
        }
        int leftdepth=maxDepth(root->left);
        int rightdepth=maxDepth(root->right);

        return 1+max(leftdepth,rightdepth);
    }
};
```

4. Output:



Problem 1.1.2: Validate Binary Search Tree

Problem Statement: Validate Binary Search Tree Check if a binary tree follows the BST property: left subtree < root < right subtree. Use DFS with a range (min, max) to validate nodes recursively in O(n) time. Alternatively, an in-order traversal should produce a strictly increasing sequence. Edge cases include a single-node tree and duplicate values.

Implementation of Code:

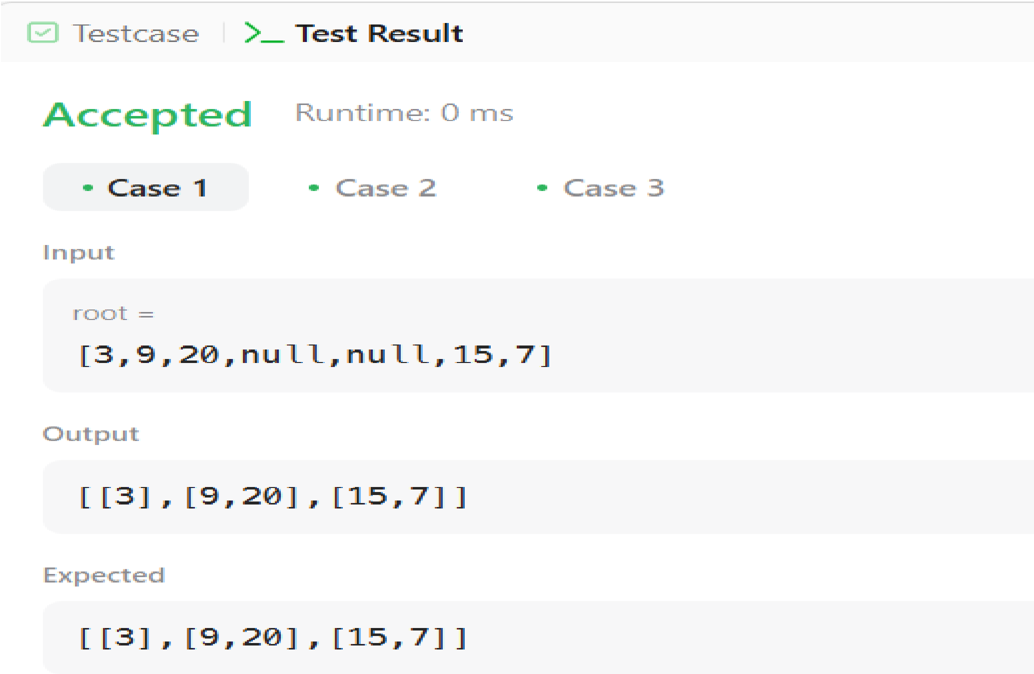
```
class Solution {
public:
    bool isValidBST(TreeNode* root) {
        return valid(root, LONG_MIN, LONG_MAX);
    }

private:
    bool valid(TreeNode* node, long minimum, long maximum) {
        if (!node) return true;

        if (!(node->val > minimum && node->val < maximum)) return false;

        return valid(node->left, minimum, node->val) && valid(node->right, node-
>val, maximum);
    }
};
```

Output:



1. **Problem 1.1.3: Symmetric Tree**

   Problem Statement: Check if a binary tree is a mirror of itself. Use recursive DFS or iterative BFS (queue) to compare corresponding nodes. The solution runs in O(n) time and O(h) space. Edge cases include an empty tree (symmetric) and a single-node tree.

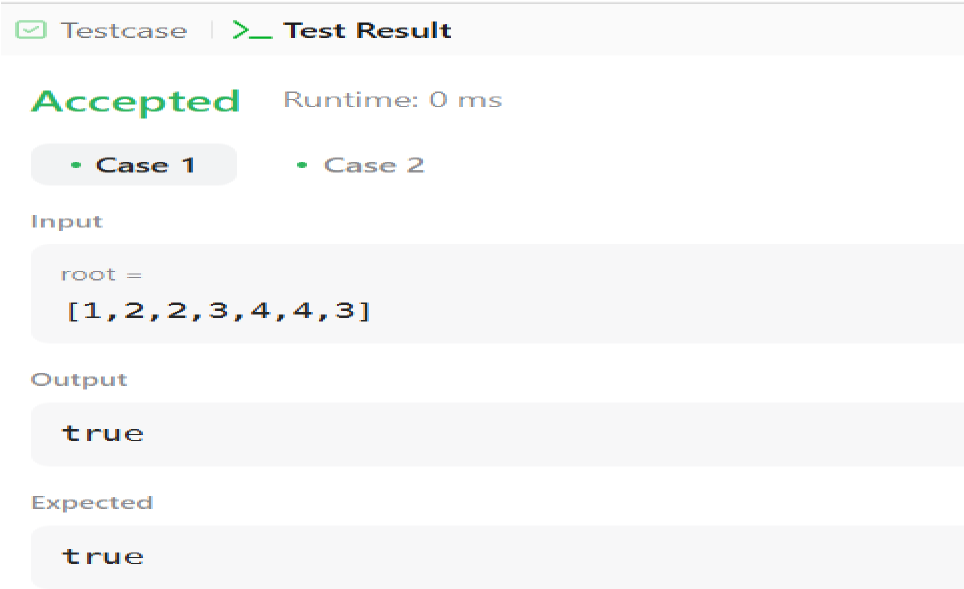
2. **Implementation of Code:**

```
class Solution {
public:
    bool isMirror(TreeNode* left, TreeNode* right) {
    if (!left && !right) return true;
    if (!left || !right) return false;
    return (left->val == right->val) && isMirror(left->left, right->right) &&
isMirror(left->right, right->left);
}

bool isSymmetric(TreeNode* root) {
    if (!root) return true;
    return isMirror(root->left, root->right);
}

};
```

3. Output:



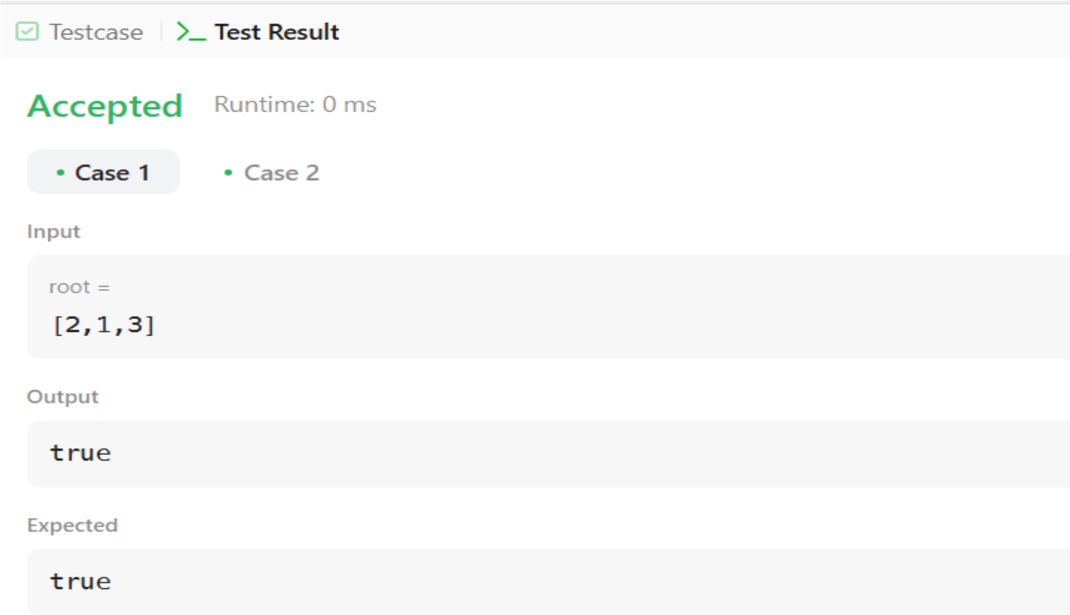
Problem 1.1.4: Binary Tree Level Order Traversal
Problem Statement: Return nodes level by level from a binary tree using BFS (queue). This runs in O(n) time and O(n) space. Edge cases include an empty tree (return []) and a single-node tree.

Implementation of code:

```
class Solution {
public:
    vector<vector<int>> levelOrder(TreeNode* root) {
        vector<vector<int>>ans;
        if(root==NULL)return ans;
        queue<TreeNode*>q;
        q.push(root);
        while(!q.empty()){
            int s=q.size();
            vector<int>v;
            for(int i=0;i<s;i++){
                TreeNode *node=q.front();
                q.pop();
                if(node->left!=NULL)q.push(node->left);
                if(node->right!=NULL)q.push(node->right);
                v.push_back(node->val);
            }
```

```
            ans.push_back(v);
        }
        return ans;
    }
};
```

Output:



Problem 1.1.5: Convert Sorted Array to Binary Search Tree
Problem Statement: Convert a sorted array into a height-balanced BST using a divide-and conquer approach. Recursively select the middle element as the root and build left and right subtrees. This runs in O(n) time and O(log n) space. Edge cases include arrays of length 1 and 2.

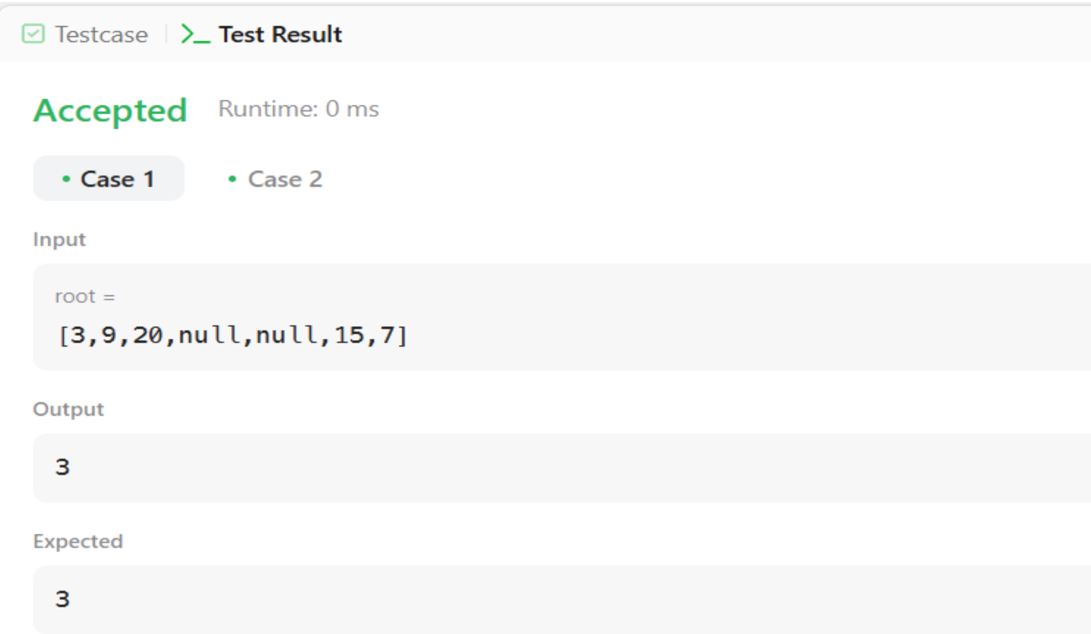
Implementation of code:

```
class Solution {
public:
    TreeNode* sortedArrayToBST(vector<int>& nums) {
        return helper(nums, 0, nums.size() - 1);
    }

private:
    TreeNode* helper(vector<int>& nums, int left, int right) {
```

```
        if (left > right) return nullptr;
        int mid = left + (right - left) / 2;
        TreeNode* root = new TreeNode(nums[mid]);
        root->left = helper(nums, left, mid - 1);
        root->right = helper(nums, mid + 1, right);
        return root;
    }
};
```

Output:



Learning Outcomes:

- Understand binary trees and BSTs.
- Implement recursive (DFS) and iterative (BFS) approaches.
- Apply divide-and-conquer, brute force, and greedy techniques.
- Use data structures like arrays, stacks, queues, and trees.
- Handle edge cases like empty or skewed trees.