DAY 6

Student Name: Shikha Singh   UID: 22BCS15316

Branch: BE-CSE   Section/Group: 620 - A

Date of Performance:26/12/24

Problem 1

1. Aim: Binary Tree Inorder Traversal
2. Code:

```cpp
#include <iostream>
#include <vector>
#include <stack>

using namespace std;
struct TreeNode {
    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
};

vector<int> inorderTraversal(TreeNode* root) {
    vector<int> result;
    if (root == nullptr) {
        return result;
    }

    result.insert(result.end(), inorderTraversal(root->left).begin());
    result.push_back(root->val);
    result.insert(result.end(), inorderTraversal(root->right).begin(),
inorderTraversal(root->right).end());
```

```cpp
        return result;
    }
    TreeNode* createTree() {
        int val;
        cout << "Enter node value (-1 for null): ";
        cin >> val;
        if (val == -1) {
            return nullptr;
        }

        TreeNode* node = new TreeNode(val);
        cout << "Enter left child of " << val << endl;
        node->left = createTree();
        cout << "Enter right child of " << val << endl;
        node->right = createTree();
        return node;
    }

    int main() {
        cout << "Create a binary tree:" << endl;
        TreeNode* root = createTree();
        vector<int> inorder = inorderTraversal(root);
        cout << "Inorder Traversal: ";
        for (int val : inorder) {
            cout << val << " ";
        }
        cout << endl;

        return 0;
    }
```

3. Output:


```
Create a binary tree:
Enter node value (-1 for null): 1
Enter left child of 1
Enter node value (-1 for null): -1
Enter right child of 1
Enter node value (-1 for null): 2
Enter left child of 2
Enter node value (-1 for null): 3
Enter left child of 3
Enter node value (-1 for null): -1
Enter right child of 3
Enter node value (-1 for null): -1
Enter right child of 2
Enter node value (-1 for null): -1
Inorder Traversal: 1 3 2
```

Problem 2

1. Aim: Count Complete Tree Nodes

2. Code:

```cpp
#include <iostream>
struct TreeNode {
    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
}; class
Solution {
public:
    int countNodes(TreeNode* root) {
if (!root) return 0;        int height =
getHeight(root);        if (height == 0)
return 1;        int left = 0, right = (1 <<
height) - 1;        while (left < right) {
int mid = left + (right - left) / 2;            if
(exists(mid, height, root)) {
```

```cpp
            left = mid + 1;        } else {
right = mid;
        }
    }        return (1 << height) -
1 + left;
    }
private:
    int getHeight(TreeNode* node)
{        int height = 0;        while
(node) {         height++;
node = node->left;
        }        return
height - 1;    }
    bool exists(int index, int height, TreeNode* node)
{        int left = 0, right = (1 << height) - 1;        for
(int i = 0; i < height; i++) {            int mid = left +
(right - left) / 2;          if (index <= mid) {
node = node->left;            right = mid;        }
else {            node = node->right;            left =
mid + 1;
        }
    }
    return node != nullptr;
} };
int main() {
    TreeNode* root = new TreeNode(1);
root->left = new TreeNode(2);    root-
>right = new TreeNode(3);    root->left-
>left = new TreeNode(4);    root->left-
>right = new TreeNode(5);    root->right-
>left = new TreeNode(6);    Solution
solution;
```

```
    std::cout << "Number of nodes: " << solution.countNodes(root) <<
std::endl;    return 0;
}
```

3. Output:

```
Number of nodes: 6
```

Problem 3

1. Aim: .Binary Tree - Find Maximum Depth

2. Code:

```cpp
struct TreeNode {
    int val;
    TreeNode *left;
    TreeNode *right;
    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
};
int maxDepth(TreeNode* root)
{    if (root == NULL) {
return 0;
    }
    return 1 + max(maxDepth(root->left), maxDepth(root->right));
}
TreeNode* createTree(const vector<int>& nodes, int index) {
if (index >= nodes.size() || nodes[index] == NULL) {
return NULL;
    }
```

```
    TreeNode* root = new TreeNode(nodes[index]);
root->left = createTree(nodes, 2 * index + 1);    root-
>right = createTree(nodes, 2 * index + 2);    return
root;
} int
main() {
    vector<int> input = {3, 9, 20, NULL, NULL, 15, 7};    TreeNode* root =
createTree(input, 0);    int depth = maxDepth(root);
    cout << "Maximum Depth: " << depth << endl;
return 0;
}
```

3. Output:

```
Maximum Depth: 3
```

Problem 4

1. Aim: Binary Tree Preorder Traversal
2. Code:

```
include <vector> #include
<iostream> struct
TreeNode {
    int val;
    TreeNode *left;
    TreeNode *right;
    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
```

```cpp
}; class
Solution {
public:
    void preorderHelper(TreeNode* root, std::vector<int>& result)
{       if (root == nullptr) {          return;
    }
        result.push_back(root->val); // Visit the root        preorderHelper(root->left, result); // Traverse left subtree        preorderHelper(root->right, result); // Traverse right subtree     }
    std::vector<int> preorderTraversal(TreeNode* root)
{       std::vector<int> result;        preorderHelper(root, result);        return result;
    } }; int
main() {
    TreeNode* root = new TreeNode(1);    root->right = new TreeNode(2);     root->right->left = new TreeNode(3);
    Solution solution;     std::vector<int> result = solution.preorderTraversal(root);     for (int val : result) {
    std::cout << val << " ";
    }
return 0;
}
```

3. Output:

```
1 2 3
```

Problem 5

1. Aim: Binary Tree - Sum of All Nodes
2. Code:

```cpp
#include <iostream>
struct TreeNode {
int val;
   TreeNode* left;
   TreeNode* right;
   TreeNode(int x) : val(x), left(nullptr), right(nullptr) { }
};
int sumOfNodes(TreeNode* root) {
   if (root == nullptr) {
return 0;
   }
   return root->val + sumOfNodes(root->left) + sumOfNodes(root->right);
}
int main() {
   TreeNode* root = new TreeNode(1);    root->left = new
TreeNode(2);    root->right = new TreeNode(3);    root->left->left
= new TreeNode(4);    root->left->right = new TreeNode(5);
root->right->right = new TreeNode(6);    int totalSum =
sumOfNodes(root);    std::cout << "The sum of all nodes is: " <<
totalSum << std::endl;    delete root->left->left; // 4    delete root-
>left->right; // 5    delete root->right->right; // 6
   delete root->left; // 2
   delete root->right; // 3
   delete root; // 1
   return 0;
}
```

3. Output:

```
The sum of all nodes is: 21
```

Problem 6

1. Aim: Same Tree

2. Code:

```cpp
struct TreeNode {
int val;
   TreeNode *left;
   TreeNode *right;
   TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
};
bool isSameTree(TreeNode* p, TreeNode* q) {
if (p == nullptr && q == nullptr) {        return
true;
   }    if (p == nullptr || q == nullptr || p->val != q-
>val) {        return false;
   }
   return isSameTree(p->left, q->left) && isSameTree(p->right, q->right);
}
#include <iostream> int
main() {
   TreeNode* p = new TreeNode(1);
p->left = new TreeNode(2);    p-
>right = new TreeNode(3);
TreeNode* q = new TreeNode(1);
q->left = new TreeNode(2);    q-
>right = new TreeNode(3);    if
(isSameTree(p, q)) {
       std::cout << "The trees are the same." << std::endl;
   } else {        std::cout << "The trees are not the same."
<< std::endl;
   }
return 0;
}
```

3. Output:

```
The trees are the same.
```

Problem 7

1. Aim: Construct Binary Tree from Preorder and Inorder Traversal
2. Code:

```cpp
#include <iostream>
#include <vector>
#include <unordered_map>
#include <queue> using
namespace std; struct
TreeNode {
    int val;
    TreeNode *left;
    TreeNode *right;
    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
}; class
Solution {
public:
    TreeNode* buildTree(vector<int>& preorder, vector<int>& inorder) {
unordered_map<int, int> inorderIndexMap;        for (int i = 0; i <
inorder.size(); ++i) {            inorderIndexMap[inorder[i]] = i;
        }
        return buildTreeHelper(preorder, 0, preorder.size() - 1,
inorderIndexMap, 0, inorder.size() - 1);
    }
private:
    TreeNode* buildTreeHelper(vector<int>& preorder, int preStart, int
preEnd,                      unordered_map<int, int>& inorderIndexMap,
int inStart, int inEnd) {        if (preStart > preEnd || inStart > inEnd) {
        return nullptr;
        }
        int rootValue = preorder[preStart];
```

```cpp
        TreeNode* root = new TreeNode(rootValue);        int rootIndex =
inorderIndexMap[rootValue];        int leftSize = rootIndex - inStart;
root->left = buildTreeHelper(preorder, preStart + 1, preStart + leftSize,
inorderIndexMap, inStart, rootIndex - 1);        root->right =
buildTreeHelper(preorder, preStart + leftSize + 1, preEnd,
                        inorderIndexMap, rootIndex + 1, inEnd);

    return root;
  }
};
void printLevelOrder(TreeNode* root) {
  if (!root) return;
  queue<TreeNode*> q;
q.push(root);    while
(!q.empty()) {
    TreeNode* node = q.front();
q.pop();      if (node) {
      cout << node->val << " ";
q.push(node->left);
      q.push(node->right);
} else {
      cout << "null ";
    }
  }
  cout << endl;
} int main() {
Solution solution;
vector<int>
preorder = {3, 9,
20, 15, 7};
vector<int> inorder
= {9, 3, 15, 20, 7};
  TreeNode* root = solution.buildTree(preorder, inorder);
printLevelOrder(root);    return 0;
```

```
}
```

3. Output:

```
3 9 20 null null 15 7 null null null null
```

Problem 8

1. Aim: Construct Binary Tree from Inorder and Postorder Traversal
2. Code:

```cpp
#include <iostream>
#include <vector> #include
<unordered_map> using
namespace std; struct
TreeNode {    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
};
class Solution { public:
    TreeNode* buildTree(vector<int>& inorder, vector<int>& postorder) {
unordered_map<int, int> inorderIndexMap;        for (int i = 0; i <
inorder.size(); ++i) {         inorderIndexMap[inorder[i]] = i;
        }

        int postIndex = postorder.size() - 1;        return
constructTree(postorder, inorderIndexMap, postIndex, 0, inorder.size() -
1);
    }
private:
    TreeNode* constructTree(vector<int>& postorder, unordered_map<int,
int>& inorderIndexMap,
```

```cpp
                  int& postIndex, int inStart, int inEnd) {        if (inStart >
inEnd) return nullptr;            int rootValue = postorder[postIndex--];
TreeNode* root = new TreeNode(rootValue);            int inIndex =
inorderIndexMap[rootValue];        root->right = constructTree(postorder,
inorderIndexMap, postIndex, inIndex + 1, inEnd);            root->left =
constructTree(postorder, inorderIndexMap, postIndex, inStart, inIndex - 1);
return root;
    }
};
void printLevelOrder(TreeNode* root) {
   if (!root) return;
   vector<TreeNode*> queue = {root};
while (!queue.empty()) {
vector<TreeNode*> nextQueue;
for (TreeNode* node : queue) {
if (node) {
        cout << node->val << " ";
nextQueue.push_back(node->left);
nextQueue.push_back(node->right);
      } else {
        cout << "null ";
      }
    }
     queue = nextQueue;
   }
} int main() {    Solution solution;
vector<int> inorder1 = {9, 3, 15, 20, 7};
vector<int> postorder1 = {9, 15, 7, 20, 3};
   TreeNode* root1 = solution.buildTree(inorder1, postorder1);
cout << "Tree 1 Level Order: ";    printLevelOrder(root1);
cout << endl;    vector<int> inorder2 = {-1};    vector<int>
postorder2 = {-1};
```

```
        TreeNode* root2 = solution.buildTree(inorder2, postorder2);
    cout << "Tree 2 Level Order: ";    printLevelOrder(root2);
    cout << endl;    return 0;
    }}
```

3. Output:

```
Tree 1 Level Order: 3 9 20 null null 15 7 null null null null
Tree 2 Level Order: -1 null null
```

Problem 9

1. Aim: Invert Binary Tree.

2. Code:

```cpp
#include <iostream>
#include <queue>
#include <vector> using
namespace std; struct
TreeNode {    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
}; class
Solution {
public:
    TreeNode* invertTree(TreeNode* root) {
        if (!root) return nullptr;
        TreeNode* temp = root->left;
root->left = root->right;        root-
>right = temp;
invertTree(root->left);
```

```cpp
invertTree(root->right);        return
root;
    }
};
TreeNode* createTree(const vector<int>& nodes) {
if (nodes.empty() || nodes[0] == -1) return nullptr;
TreeNode* root = new TreeNode(nodes[0]);
queue<TreeNode*> q;     q.push(root);    int i = 1;
    while (i < nodes.size()) {
TreeNode* current = q.front();
q.pop();

    if (nodes[i] != -1) {            current->left =
new TreeNode(nodes[i]);
q.push(current->left);
    }
    ++i;

    if (i < nodes.size() && nodes[i] != -1) {            current->right = new
TreeNode(nodes[i]);            q.push(current->right);
    }
    ++i;    }    return root; } void
printLevelOrder(TreeNode* root) {
  if (!root) return;
  queue<TreeNode*> q;
q.push(root);    while (!q.empty())
{        TreeNode* current =
q.front();        q.pop();        if
(current) {            cout << current-
>val << " ";        q.push(current-
>left);
      q.push(current->right);
} else {          cout << "null ";
    }
```

```
        }
        cout << endl;
    } int main() {
    Solution solution;
        vector<int> treeNodes = {4, 2, 7, 1, 3, 6, 9};
    TreeNode* root = createTree(treeNodes);    cout
    << "Original Tree Level Order: ";
    printLevelOrder(root);
        TreeNode* invertedRoot = solution.invertTree(root);
    cout << "Inverted Tree Level Order: ";
    printLevelOrder(invertedRoot);    return 0;
    }
```

3. Output:

```
Original Tree Level Order: 4 2 7 1 3 6 9 null null null null null null null null
Inverted Tree Level Order: 4 7 2 9 6 3 1 null null null null null null null null
```

Problem 10

1. Aim: Path Sum
2. Code:

```cpp
#include <iostream>
#include <queue>
#include <vector> using
namespace std; struct
TreeNode {
    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
}; class
Solution {
public:
```

```cpp
    bool hasPathSum(TreeNode* root, int targetSum) {
if (!root) return false;        if (!root->left && !root-
>right) {           return root->val == targetSum;
    }
    int remainingSum = targetSum - root->val;
    return hasPathSum(root->left, remainingSum) ||
hasPathSum(root>right, remainingSum);
    }
};
TreeNode* createTree(const vector<int>& nodes) {
if (nodes.empty() || nodes[0] == -1) return nullptr;
   TreeNode* root = new TreeNode(nodes[0]);
   queue<TreeNode*> q;
q.push(root);     int i = 1;
   while (i < nodes.size()) {
TreeNode* current = q.front();
q.pop();

    if (nodes[i] != -1) {            current->left =
new TreeNode(nodes[i]);
q.push(current->left);
    }
    ++i;        if (i < nodes.size() && nodes[i] !=
-1) {          current->right = new
TreeNode(nodes[i]);          q.push(current-
>right);
    }
    ++i;    }    return root; } void
printLevelOrder(TreeNode* root) {
   if (!root) return;
   queue<TreeNode*> q;
q.push(root);     while (!q.empty())
{       TreeNode* current =
```

```cpp
        q.front();      q.pop();        if
(current) {             cout << current-
>val << " ";          q.push(current-
>left);
        q.push(current->right);
} else {          cout << "null ";
        }
    }
    cout << endl;
}
int main() {
    Solution solution;      vector<int> treeNodes = {5, 4, 8, 11, -1, 13,
4, 7, 2, -1, -1, -1, 1};      int targetSum = 22;
    TreeNode* root = createTree(treeNodes);      cout << "Tree Level Order:
";      printLevelOrder(root);      bool result = solution.hasPathSum(root,
targetSum);      cout << "Has Path Sum = " << targetSum << ": " << (result
? "true" :
"false") << endl;
    return 0;
    }
```

3. Output:

```
Tree Level Order: 5 4 8 11 null 13 4 7 2 null null null 1 null null null null null null
Has Path Sum = 22: true
```