DAY 6

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Date: 26/12/24 Section/Group: 620 - B

Problem 1

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

```
#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());
```

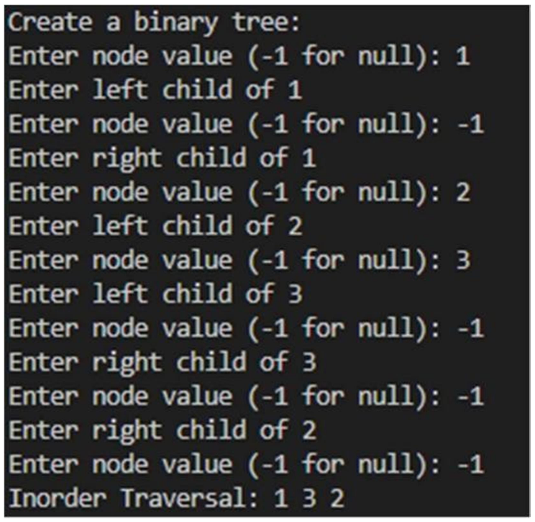
```
    return result;
}
TreeNode* createTree() {
    int val;
    cout << "Enter node value (-1 for null): ";
    cin >> val;
    if (val == -1) {
        return nullptr;
    }

    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

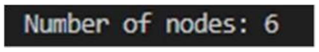
1. Aim: Count Complete Tree Nodes
2. Code:

```
#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)) {
```

```
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

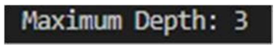
1. Aim: .Binary Tree - Find Maximum Depth

2. Code:

```
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:



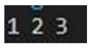
```
Maximum Depth: 3
```

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) {}
}; 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:



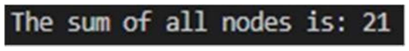
```
1 2 3
```

Problem 5

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

```
#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
```

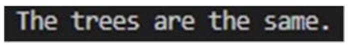
Problem 6

1. Aim: Same Tree

2. Code:

```
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:

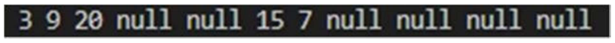
```
#include <iostream>
#include <vector>
#include <unordered_map>
#include <queue> using
namespace std; struct
TreeNode {
   int val;
   TreeNode *left;
   TreeNode *right;
   TreeNode(int x) : val(x), left(NULL), right(NULL) {}
}; class
Solution {
public:
   TreeNode* buildTree(vector<int>& preorder, 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];
```

```
        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

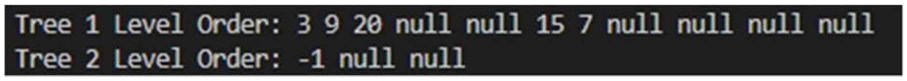
1. Aim: Construct Binary Tree from Inorder and Postorder Traversal
2. Code:

```
#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,
                    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.

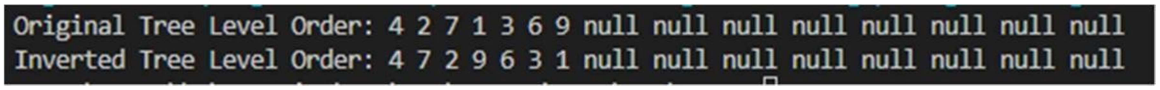
2. Code:

```
#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);
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
```

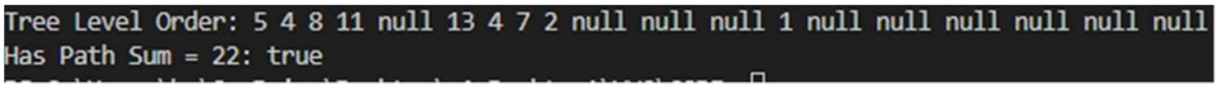
Problem 10

1. Aim: Path Sum
2. Code:

```
#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:
   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 =
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
```