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ASSIGNMENT-6

## DAY 6 (Thursday)

### Very Easy:

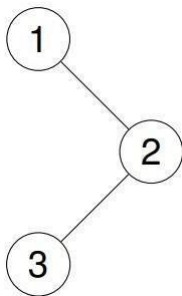
#### 1. Binary Tree Inorder Traversal

Given the root of a binary tree, return the inorder traversal of its nodes' values.

##### Example 1:

Input: root = [1,null,2,3]

Output: [1,3,2] Explanation:



### CODE:

```
#include <iostream>
#include <vector>
using namespace std;

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

void inorder(TreeNode* root, vector<int>& result) {
    if (!root) return;
    inorder(root->left, result);
    result.push_back(root->val);
    inorder(root->right, result);
}

vector<int> inorderTraversal(TreeNode* root) {
    vector<int> result;
    inorder(root, result);
    return result;
}
```

```
int main() {  
    TreeNode* root = new TreeNode(1);  
    root->right = new TreeNode(2);  
    root->right->left = new TreeNode(3);  
  
    vector<int> result = inorderTraversal(root);  
    for (int val : result) {  
        cout << val << " ";  
    }  
    cout << endl;  
  
    return 0;  
}
```

OUTPUT:



```
1 3 2
```

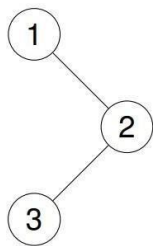
## 2.Binary Tree Preorder Traversal

Given the root of a binary tree, return the preorder traversal of its nodes' values.

### Example 1:

**Input:** root = [1,null,2,3]

**Output:** [1,2,3]



## CODE:

```
#include <iostream>

#include <vector>

using namespace std;

struct TreeNode {

    int val;

    TreeNode* left;

    TreeNode* right;

    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}

};

void preorder(TreeNode* root, vector<int>& result) {

    if (!root) return;

    result.push_back(root->val);

    preorder(root->left, result);

    preorder(root->right, result);

}

vector<int> preorderTraversal(TreeNode* root) {

    vector<int> result;

    preorder(root, result);

    return result;
```

```
}
```

```
int main() {
```

```
    TreeNode* root = new TreeNode(1);
```

```
    root->right = new TreeNode(2);
```

```
    root->right->left = new TreeNode(3);
```

```
    vector<int> result = preorderTraversal(root);
```

```
    for (int val : result) {
```

```
        cout << val << " ";
```

```
    }
```

```
    cout << endl;
```

```
    return 0;
```

```
}
```

**OUTPUT:**



```
1 2 3
```

### 3. Binary Tree - Sum of All Nodes

Given the root of a binary tree, you need to find the sum of all the node values in the binary tree.

#### Example 1:

**Input:** root = [5, 2, 6, 1, 3, 4, 7]

**Output:** 28

**Explanation:** The sum of all nodes is  $5 + 2 + 6 + 1 + 3 + 4 + 7 = 28$ .

#### CODE:

```
#include <iostream>
```

```
using namespace std;
```

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

```
int sumOfAllNodes(TreeNode* root) {  
    if (!root) return 0;  
    return root->val + sumOfAllNodes(root->left) + sumOfAllNodes(root->right);  
}
```

```
int main() {  
    TreeNode* root = new TreeNode(5);  
    root->left = new TreeNode(2);  
    root->right = new TreeNode(6);  
    root->left->left = new TreeNode(1);  
    root->left->right = new TreeNode(3);  
    root->right->left = new TreeNode(4);  
    root->right->right = new TreeNode(7);  
  
    cout << "Sum of all nodes: " << sumOfAllNodes(root) << endl;  
  
    return 0;  
}
```

OUTPUT:

```
Sum of all nodes: 28
```

*Easy:*

## 1. Same Tree

Two binary trees are considered the same if they are structurally identical, and the nodes have the same value.

### Example 1:

**Input:** p = [1,2,3], q = [1,2,3]

**Output:** true CODE:

```
#include <iostream>
using namespace std;
```

```
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 && !q) return true;
    if (!p || !q || p->val != q->val) return false;
    return isSameTree(p->left, q->left) && isSameTree(p->right, q->right);
}

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);

    cout << (isSameTree(p, q) ? "true" : "false") << endl;
    return 0;
}
```

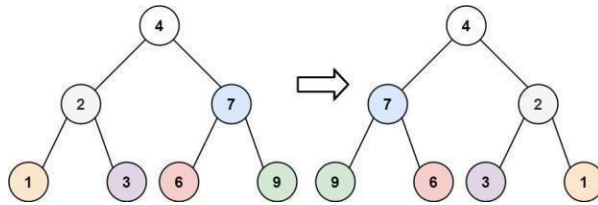
OUTPUT:



## 2. Invert Binary Tree

Given the root of a binary tree, invert the tree, and return its root

## Example 1:



**Input:** root = [4,2,7,1,3,6,9]

**Output:** [4,7,2,9,6,3,1]

### CODE:

```
#include <iostream>
using namespace std;
```

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

```
TreeNode*
invertTree(TreeNode*
root) {
    if (!root) return
    nullptr;
    swap(root->left,
root->right);
    invertTree(root->
left);
    invertTree(root->
right);
    return root;
}
```

```
void
preorderTraversal(Tree
Node* root) {
    if (!root) return;
    cout << root->val
<< " ";
```

```
preorderTraversal(root
->left);
```

```
preorderTraversal(root
```

```
->right);
}

int main() {
    TreeNode* root =
    new TreeNode(4);
    root->left = new
    TreeNode(2);
    root->right = new
    TreeNode(7);
    root->left->left =
    new TreeNode(1);
    root->left->right =
    new TreeNode(3);
    root->right->left =
    new TreeNode(6);
    root->right->right =
    new TreeNode(9);

    root =
    invertTree(root);

    preorderTraversal(root
    );
    cout << endl;

    return 0;
}
OUTPUT:
```

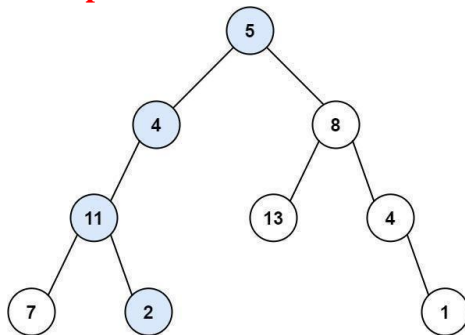
```
4 7 9 6 2 3 1
```

### 3. Path Sum

Given a binary tree and a sum, return true if the tree has a root-to-leaf path such that adding up all the values along the path equals the given sum. Return false if no such path can be found.



## Example 1:



**Input:** root = [5,4,8,11,null,13,4,7,2,null,null,null,1], targetSum = 22

**Output:** true

**Explanation:** The root-to-leaf path with the target sum is shown.

### CODE:

```
#include <iostream>
```

```
using namespace std;
```

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

```
bool hasPathSum(TreeNode* root, int targetSum) {
    if (!root) return false;
    if (!root->left && !root->right) return root->val == targetSum;
    return hasPathSum(root->left, targetSum - root->val) ||
    hasPathSum(root->right, targetSum - root->val);
}
```

```
int main() {
    TreeNode* root = new TreeNode(5);
    root->left = new TreeNode(4);
    root->right = new TreeNode(8);
    root->left->left = new TreeNode(11);
    root->left->left->left = new TreeNode(7);
    root->left->left->right = new TreeNode(2);
    root->right->left = new TreeNode(13);
    root->right->right = new TreeNode(4);
    root->right->right->right = new TreeNode(1);

    int targetSum = 22;

    cout << (hasPathSum(root, targetSum) ? "true" : "false") << endl;

    return 0;
}
```

OUTPUT:



*Medium:*

## 1. Construct Binary Tree from Preorder and Inorder Traversal

Given two integer arrays preorder and inorder where preorder is the preorder traversal of a binary tree and inorder is the inorder traversal of the same tree, construct and return the binary tree.

### Example 1:

**Input:** preorder = [3,9,20,15,7], inorder = [9,3,15,20,7]

**Output:** [3,9,20,null,null,15,7]

### CODE:

```
#include <iostream>
#include <unordered_map>
#include <vector>
using namespace std;
```

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

```
TreeNode* buildTreeHelper(vector<int>& preorder, int preStart, int preEnd,
                          vector<int>& inorder, int inStart, int inEnd,
                          unordered_map<int, int>& inMap) {
    if (preStart > preEnd || inStart > inEnd) return nullptr;
```

```
    TreeNode* root = new TreeNode(preorder[preStart]);
    int inRoot = inMap[root->val];
    int numsLeft = inRoot - inStart;
```

```
    root->left = buildTreeHelper(preorder, preStart + 1, preStart + numsLeft, inorder, inStart, inRoot - 1,
                                inMap);
```

```
    root->right = buildTreeHelper(preorder, preStart + numsLeft + 1, preEnd, inorder, inRoot + 1, inEnd,
                                  inMap);
```

```
    return root;
}
```

```
TreeNode* buildTree(vector<int>& preorder, vector<int>& inorder) {
    unordered_map<int, int> inMap;
```

```

    for (int i = 0; i < inorder.size(); i++) inMap[inorder[i]] = i;
    return buildTreeHelper(preorder, 0, preorder.size() - 1, inorder, 0, inorder.size() - 1, inMap);
}

void printInorder(TreeNode* root) {
    if (!root) return;
    printInorder(root->left);
    cout << root->val << " ";
    printInorder(root->right);
}

int main() {
    vector<int> preorder = {3, 9, 20, 15, 7};
    vector<int> inorder = {9, 3, 15, 20, 7};

    TreeNode* root = buildTree(preorder, inorder);

    printInorder(root);
    cout << endl;

    return 0;
}

```



## 2. Construct Binary Tree from Inorder and Postorder Traversal

Given two integer arrays inorder and postorder where inorder is the inorder traversal of a binary tree and postorder is the postorder traversal of the same tree, construct and return the binary tree.

### Example 1:

**Input:** inorder = [9,3,15,20,7], postorder = [9,15,7,20,3]

**Output:** [3,9,20,null,null,15,7]

### CODE:

```

#include <iostream>
#include <unordered_map>
#include <vector>
using namespace std;

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

TreeNode* buildTreeHelper(vector<int>& inorder, int inStart, int inEnd,
    vector<int>& postorder, int postStart, int postEnd,

```

```

        unordered_map<int, int>& inMap) {
    if (inStart > inEnd || postStart > postEnd) return nullptr;

    TreeNode* root = new TreeNode(postorder[postEnd]);
    int inRoot = inMap[root->val];
    int numsLeft = inRoot - inStart;

    root->left = buildTreeHelper(inorder, inStart, inRoot - 1, postorder, postStart, postStart + numsLeft - 1, inMap);
    root->right = buildTreeHelper(inorder, inRoot + 1, inEnd, postorder, postStart + numsLeft, postEnd - 1, inMap);

    return root;
}

TreeNode* buildTree(vector<int>& inorder, vector<int>& postorder) {
    unordered_map<int, int> inMap;
    for (int i = 0; i < inorder.size(); i++) {
        inMap[inorder[i]] = i;
    }
    return buildTreeHelper(inorder, 0, inorder.size() - 1, postorder, 0, postorder.size() - 1, inMap);
}

void printInorder(TreeNode* root) {
    if (!root) return;
    printInorder(root->left);
    cout << root->val << " ";
    printInorder(root->right);
}

int main() {
    vector<int> inorder = {9, 3, 15, 20, 7};
    vector<int> postorder = {9, 15, 7, 20, 3};

    TreeNode* root = buildTree(inorder, postorder);
    printInorder(root); // Output: 9 3 15 20 7
    cout << endl;

    return 0;
}

```

9 3 15 20 7

### 3. Sum Root to Leaf Numbers

You are given the root of a binary tree containing digits from 0 to 9 only.

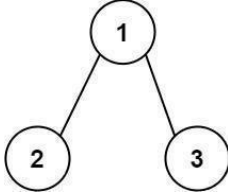
Each root-to-leaf path in the tree represents a number.

For example, the root-to-leaf path 1 -> 2 -> 3 represents the number 123.

Return the total sum of all root-to-leaf numbers. Test cases are generated so that the answer will fit in a 32-bit integer.

A leaf node is a node with no children.

**Example 1:**



**Input:** root = [1,2,3] **Output:** 25 **Explanation:**

The root-to-leaf path 1->2 represents the number 12.

The root-to-leaf path 1->3 represents the number 13.

Therefore, sum = 12 + 13 = 25.

**CODE:**

```

#include <iostream>
using namespace std;
struct TreeNode {
    int val;
    TreeNode* left;
    TreeNode* right;
    TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
};

int sumNumbersHelper(TreeNode* root, int currentSum) {
    if (!root) return 0;

    currentSum = currentSum * 10 + root->val;

    if (!root->left && !root->right) return currentSum; // Leaf node

    return sumNumbersHelper(root->left, currentSum) + sumNumbersHelper(root->right, currentSum);
}

int sumNumbers(TreeNode* root) {
    return sumNumbersHelper(root, 0);
}

int main() {
    TreeNode* root = new TreeNode(1);
    root->left = new TreeNode(2);
    root->right = new TreeNode(3);

    cout << sumNumbers(root) << endl;

    return 0;
}
  
```

**Hard:**

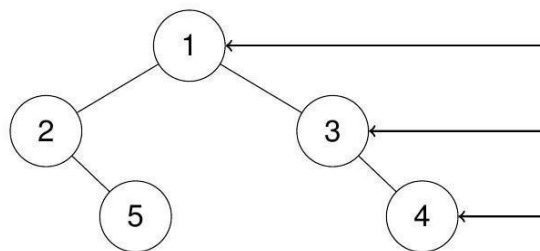
## 1. Binary Tree Right Side View

Given the root of a binary tree, imagine yourself standing on the right side of it, return the values of the nodes you can see ordered from top to bottom.

**Example 1:**

**Input:** root = [1,2,3,null,5,null,4]

**Output:** [1,3,4]



**Explanation:**

**CODE:**

```
#include <iostream>
#include <vector>
#include <queue> using
namespace std;
```

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

```
vector<int> rightSideView(TreeNode* root) {
    vector<int> result;
    if (!root) return result;
```

```
    queue<TreeNode*> q;
    q.push(root);
```


```
    while (!q.empty()) {        int
    levelSize = q.size();        for (int i = 0;
    i < levelSize; i++) {
```

```
TreeNode* current = q.front();
q.pop();
    // Add the last node of the current level to the result
    if (i == levelSize - 1) result.push_back(current->val);

    if (current->left) q.push(current->left);
    if (current->right) q.push(current->right);
}
}
return result;
}

int main() {
    TreeNode* root = new TreeNode(1);
    root->left = new TreeNode(2);    root->right
    = new TreeNode(3);    root->left->right =
    new TreeNode(5);
    root->right->right = new TreeNode(4);

    vector<int> result = rightSideView(root);
    for (int val : result) {
        cout << val << " ";
    }
    // Output: 1 3 4
    return 0;
}
```



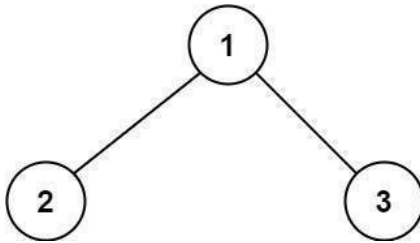
## 2. Binary Tree Maximum Path Sum

A path in a binary tree is a sequence of nodes where each pair of adjacent nodes in the sequence has an edge connecting them. A node can only appear in the sequence at most once. Note that the path does not need to pass through the root.

The path sum of a path is the sum of the node's values in the path.

Given the root of a binary tree, return the maximum path sum of any non-empty path.

### Example 1:



**Input:** root = [1,2,3]

**Output:** 6

**Explanation:** The optimal path is 2 -> 1 -> 3 with a path sum of  $2 + 1 + 3 = 6$ .

**CODE:**

```
#include <iostream> #include
```

```
<climits>
```

```
using namespace std;
```

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

```
int maxPathSumHelper(TreeNode* root, int& maxSum) {
    if (!root) return 0;
```

```
    // Compute maximum path sums for left and right subtrees
    int leftMax = max(0, maxPathSumHelper(root->left, maxSum));
    int rightMax = max(0, maxPathSumHelper(root->right, maxSum));
```

```
    // Update the overall maximum path sum
    maxSum = max(maxSum, leftMax + rightMax + root->val);
```

```
    // Return the maximum path sum including the current node
    return max(leftMax, rightMax) + root->val;
}
```

```
int maxPathSum(TreeNode* root) {
    int maxSum = INT_MIN;
    maxPathSumHelper(root, maxSum);
    return maxSum;
}
```

```
int main() {
```



```
TreeNode* root = new TreeNode(1);    root->
left = new TreeNode(2);
    root->right = new TreeNode(3);

    cout << maxPathSum(root) << endl; // Output: 6
    return 0;
}
```

6

**Very Hard:**

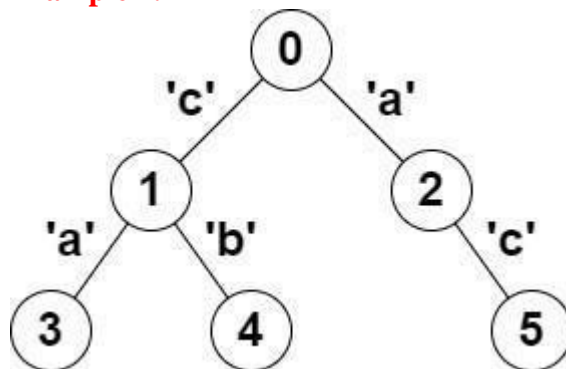
## 1. Count Paths That Can Form a Palindrome in a Tree

You are given a tree (i.e. a connected, undirected graph that has no cycles) rooted at node 0 consisting of  $n$  nodes numbered from 0 to  $n - 1$ . The tree is represented by a 0-indexed array `parent` of size  $n$ , where `parent[i]` is the parent of node  $i$ . Since node 0 is the root, `parent[0] == -1`. You are also given a string `s` of length  $n$ , where `s[i]` is the character assigned to the edge between  $i$  and `parent[i]`. `s[0]` can be ignored.

Return the number of pairs of nodes  $(u, v)$  such that  $u < v$  and the characters assigned to edges on the path from  $u$  to  $v$  can be rearranged to form a palindrome.

A string is a palindrome when it reads the same backwards as forwards.

**Example 1:**



**Input:** `parent = [-1,0,0,1,1,2], s = "acaabc"`

**Output:** 8

**Explanation:** The valid pairs are:

- All the pairs  $(0,1)$ ,  $(0,2)$ ,  $(1,3)$ ,  $(1,4)$  and  $(2,5)$  result in one character which is always a palindrome.
- The pair  $(2,3)$  result in the string "aca" which is a palindrome.
- The pair  $(1,5)$  result in the string "cac" which is a palindrome.
- The pair  $(3,5)$  result in the string "acac" which can be rearranged into the palindrome "acca".

## CODE:

```
#include <iostream>
#include <vector>
#include <unordered_map> #include
<unordered_set>
using namespace std;

// Helper function to perform DFS and count palindromic paths
void dfs(int node, int mask, const vector<vector<int>>& graph, const string& s, unordered_map<int,
int>& count, int& result) {
    // Update result based on the current mask
    result += count[mask];    for (int i = 0; i <
26; ++i) {
        result += count[mask ^ (1 << i)];
    }

    // Increment the count for the current mask
    count[mask]++;

    // Recur for child nodes
    for (int child : graph[node]) {
        dfs(child, mask ^ (1 << (s[child] - 'a')), graph, s, count, result);
    }

    // Decrement the count to backtrack
    count[mask]--;
}

int countPalindromePaths(vector<int>& parent, string s) {
    int n = parent.size();    vector<vector<int>> graph(n);
    for (int i = 1; i < n; ++i) {
        graph[parent[i]].push_back(i);
    }

    unordered_map<int, int> count;
    count[0] = 1; // Initial mask (no characters)
    int result = 0;
    dfs(0, 0, graph, s, count, result);
    return result;
}

int main() {
    vector<int> parent = {-1, 0, 0, 1, 1, 2};
    string s = "acaabc";
```

```
cout << countPalindromePaths(parent, s) << endl; // Output: 8
return 0;
}
```

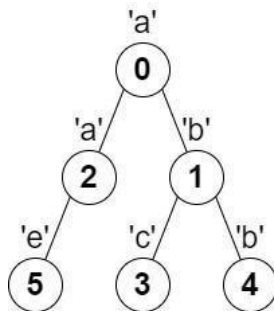
8

## 2. Longest Path With Different Adjacent Characters

You are given a tree (i.e. a connected, undirected graph that has no cycles) rooted at node 0 consisting of  $n$  nodes numbered from 0 to  $n - 1$ . The tree is represented by a 0-indexed array `parent` of size  $n$ , where `parent[i]` is the parent of node  $i$ . Since node 0 is the root, `parent[0] == -1`. You are also given a string `s` of length  $n$ , where `s[i]` is the character assigned to node  $i$ .

Return the length of the longest path in the tree such that no pair of adjacent nodes on the path have the same character assigned to them.

### Example 1:



**Input:** `parent = [-1,0,0,1,1,2]`, `s = "abacbe"`

**Output:** 3

**Explanation:** The longest path where each two adjacent nodes have different characters in the tree is the path: 0 -> 1 -> 3. The length of this path is 3, so 3 is returned. It can be proven that there is no longer path that satisfies the conditions.

### CODE:

```
from collections import defaultdict
```

```
def longestPath(parent, s):
```

```
    n = len(parent)
```

```
    adj = defaultdict(list)
```

```
    # Build the adjacency list of the tree
```

```
    for i in range(1, n):
```

```
        adj[parent[i]].append(i)
```

```
    # This will store the longest path starting from each node
```

```
    longest = [0] * n
```

```
    def dfs(node):
```

```
        first_max, second_max = 0, 0
```

```
# Explore all the children of the current node
for child in adj[node]:
    child_path = dfs(child)

    # Only consider the child's path if the characters are different
    if s[child] != s[node]:
        if child_path > first_max:
            second_max = first_max
            first_max = child_path
        elif child_path > second_max:
            second_max = child_path

    # The longest path that passes through this node is the sum of first_max and second_max + 1
    (for the current node itself)
    longest[node] = first_max + 1
    # Return the length of the longest path for
    the subtree rooted at this node
    return first_max + 1

# Start DFS from the root (node 0)
dfs(0)

# The answer is the longest path in the tree
return max(longest)

# Example usage
parent = [-1, 0, 0, 1, 1, 2]
s = "abacbe"
print(longestPath(parent, s)) # Output: 3
```