**TREE QUESTIONS**

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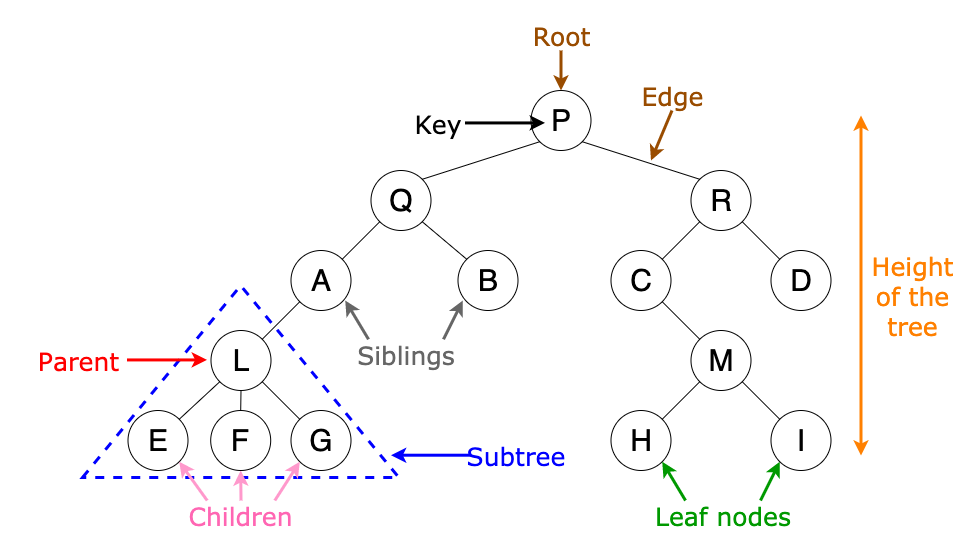
# **Theory**

## What is Tree data structure?

A tree is a hierarchical data structure that starts with a root node and consists of connected nodes. It organizes elements in a parent-child relationship, where each node can have multiple children. It is widely used for representing hierarchical relationships and enables efficient searching, insertion, and deletion operations.

## What are components of tree?

1. **Root:** A tree has a unique node called the root, which serves as the starting point of the tree. All other nodes in the tree are descendants of the root.
2. **Nodes:** A tree consists of nodes that are connected by edges. Each node can have zero or more child nodes. Nodes other than the root are referred to as internal nodes, while nodes without any children are called leaf nodes or leaves.
3. **Edges:** Edges are the connections between nodes in a tree. They represent the relationships between the nodes. Each node (except the root) has exactly one incoming edge from its parent node, and it may have zero or more outgoing edges to its child nodes.
4. **Parent and Child Nodes:** Each node in a tree (except the root) has a unique parent node, which is the node directly above it. The parent node is connected to its child nodes through edges. Conversely, child nodes are the nodes directly below a parent node.
5. **Ancestors and Descendants:** An ancestor of a node is any node that exists on the path from the root to that node, excluding the node itself. A descendant of a node is any node that can be reached by following edges from the node, again excluding the node itself.
6. **Path:** A path in a tree is a sequence of nodes connected by edges. It represents the traversal from one node to another within the tree.
7. **Depth and Height:** The depth of a node is the length of the path from the root to that node. The height of a tree is the maximum depth of any node in the tree. The height represents the length of the longest path from the root to a leaf node.
8. **Subtree:** A subtree is a portion of the tree that consists of a node and all its descendants, including their child nodes and their child nodes, and so on.
9. **Degree:** The degree of a node is the number of its child nodes. A node with a degree of zero is a leaf node, while a node with a degree greater than zero is an internal node.



## Binary Tree

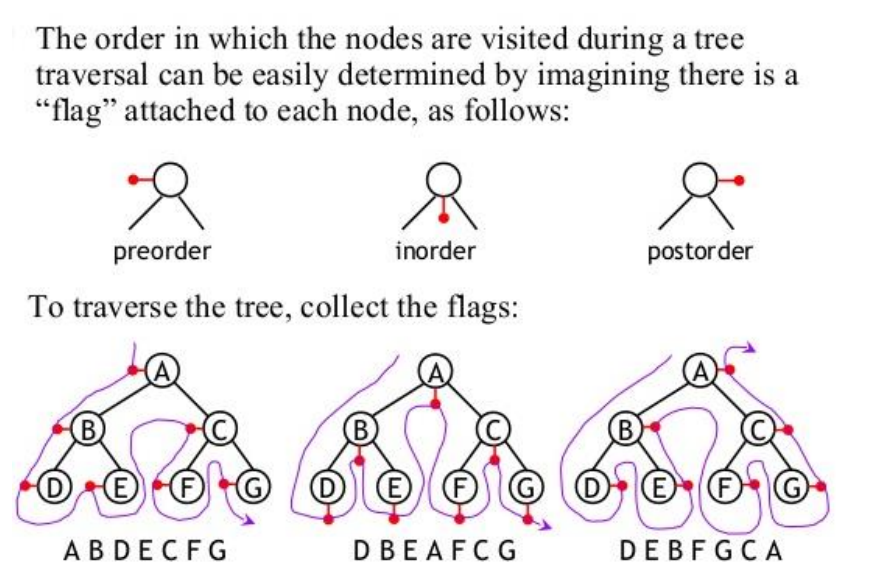
A binary tree is a tree data structure where each node can have at most two children, the left child and the right child.

Some types of binary trees are:-

1. **Full Binary Tree:** A full binary tree is a binary tree in which every node has either 0 or 2 children. In other words, every level of the tree is completely filled, except for the last level, which may or may not be full.
2. **Complete Binary Tree:** A complete binary tree is a binary tree in which all levels are completely filled, except possibly for the last level, which is filled from left to right. It ensures that the nodes are as balanced as possible.
3. **Perfect Binary Tree:** A perfect binary tree is a binary tree in which all levels are completely filled with maximum possible nodes. It is a type of complete binary tree with exactly 2^h - 1 nodes, where h is the height of the tree.
4. **Balanced Binary Tree:** A balanced binary tree is a binary tree in which the difference in height between the left and right subtrees of any node is at most 1. It ensures that the height of the tree remains relatively small, resulting in efficient operations.
5. **Degenerate (or Pathological) Binary Tree:** A degenerate binary tree is a binary tree in which each parent node has only one child (either left or right). It essentially becomes a linked list.

## Tree traversal

1. Inorder traversal ( left, root, right)
2. Preorder traversal ( root, left , right)
3. Postorder traversal ( root, left, right)



## Binary Search Tree

A binary search tree is a type of binary tree that follows a specific ordering of the nodes. In a binary search tree, the left child of a node contains values that are less than the parent node, and the right child contains values that are greater than the parent node. This ordering property allows for efficient searching, insertion, and deletion operations.

For BST inorder traversal gives numbers in ascending order.

## Use cases of Tree and its use in system design.

1. **File System:** Trees are widely used to represent file systems in operating systems. Each directory is represented as a node in the tree, with subdirectories and files as its children.
2. **Routing Algorithms:** Trees are employed in routing algorithms used in networking and telecommunications systems. Examples include the spanning tree protocol (STP) for network redundancy and the hierarchical routing protocol used in the Internet's Border Gateway Protocol (BGP) to organize routing tables.
3. **Data Compression:** Huffman coding is a popular technique for data compression that involves constructing a binary tree where the leaves represent characters and their frequency of occurrence. The resulting tree is used to encode the data in a way that minimizes the amount of storage required.
4. **Compiler Design:** In compiler design, a syntax tree is used to represent the structure of a program.
5. **Database Indexing:** B-trees and other tree structures are used in database indexing to efficiently search for and retrieve data.
6. **User Interfaces:** Trees are utilized in the design of graphical user interfaces (GUIs) to represent the hierarchy of UI elements. This allows for efficient event handling, layout management, and navigation within the UI.

# LEVEL 1: **EASY**

### Implement basic functionalities of tree in python.

Insert, Inorder traversal and search.

### For a tree write its inorder traversal. Store value in array.

Link: <https://leetcode.com/problems/binary-tree-inorder-traversal/description/>

### Two sum problem. Given an array of integers and a target, return the indices of two numbers in array which add up to the target. All integers in the array occur only once.

### Given two arrays and given a value target. The problem is to count all pairs comprising of one element from each array such that they add up to target value.

### Write a function to check if two strings are anagrams (anagrams are words that can be formed by rearranging letters of each other).

### Given an array of integers, find the count of pair of integers whose sum gives 0 reminder when divided by 5.

### Print all permutations of a string.

### Print all paths in 2D grid

You are given a 2D grid (m × n), you are at the top left point and you need to reach bottom right point. You can only go right or down. Count all possible ways and also print all the paths.

### Print all paths in 2D grid with diagonal move too

You are given a 2D grid (m × n), you are at the top left point and you need to reach bottom right point. You can only go right or down and diagonally down too. Print all the paths.

# LEVEL 2: **Medium**

### Find length of longest subarray whose sum is 0.

# LEVEL 3: **Difficult**

### Write a Python function to find count of subarrays whose xor value is m.

# **SOLUTIONS:**

## **LEVEL 1:**

1. Tree implementation

class Node:

    def \_\_init\_\_(self,data):

*self*.data = data

*self*.left = None

*self*.right = None

class BST:

    def \_\_init\_\_(self):

*self*.root = None

    def insert(self,data):

        def insert\_recursive(node,data):

            if node is None:

                return Node(data)

            if data < node.data:

                node.left = insert\_recursive(node.left,data)

            else:

                node.right = insert\_recursive(node.right,data)

            return node

*self*.root = insert\_recursive(*self*.root, data)

    def inorder(self):

        def inorder\_traversal(node):

            if node is not None:

                inorder\_traversal(node.left)

                print(node.data,end=" ")

                inorder\_traversal(node.right)

        inorder\_traversal(*self*.root)

    def search(self,data):

        def search\_recursive(node,data):

            if node is None:

                return False

            if node.data == data:

                return True

            if data < node.data:

                return search\_recursive(node.left,data)

            else:

                return search\_recursive(node.right,data)

        return search\_recursive(*self*.root,data)

bst = BST()

bst.insert(3)

bst.insert(5)

bst.insert(0)

bst.insert(9)

bst.inorder()

print(bst.search(9))

1. Inorder Traversal

**While using global array or variable, always remember to clear it first before use. Else if we run code for more than one output in global array answers get appended for all test cases.**

*#Method 1 ( use of global variable)*

class Solution:

    res=[]

    def inOrder(self,root):

        if root is None:

            return

*self*.inOrder(root.left)

*self*.res.append(root.val)

*self*.inOrder(root.right)

    def inorderTraversal(self, root: Optional[TreeNode]) -> List[int]:

        self.res.clear() #clear the data

        self.inOrder(root)

        return self.res

*#Method 2 (without global variable)*

class Solution:

    def inorderTraversal(self, root: Optional[TreeNode]) -> List[int]:

        res = []

        if root is None:

            return res

        res+=self.inorderTraversal(root.left)

        res+=[root.val]

        res+=self.inorderTraversal(root.right)

        return res

*# Method 3 : One liner*

class Solution:

    def inorderTraversal(self, root: Optional[TreeNode]) -> List[int]:

        return  self.inorderTraversal(root.left) + [root.val] + self.inorderTraversal(root.right) if root else []

1. Two sum

from collections import defaultdict

def two\_sum(arr,target):

    ans =[]

    d = defaultdict(int) *# key:value = number:index*

    for i in range(len(arr)):

        d[arr[i]]=i

    for i in d:

        if target-i in d:

            ans.append((d[i],d[target-i]))

    return ans

ans = two\_sum([2,3,6,1,5,4],7)

print(\*ans)

1. Count Pair sum

from collections import defaultdict

class Solution:

    def countPairs(self,arr1, arr2, target):

        ans\_count=0

        d1,d2=defaultdict(int),defaultdict(int) *#key:element = value:count*

        for i in arr1:

            d1[i]+=1

        for i in arr2:

            d2[i]+=1

        for i in d1:

            if(d2[target-i]):

                ans\_count += d1[i]\*d2[target-i] *#eg in arr1 2 is 2 times and in arr2*

*#8 is 2 times so 2\*2=4 pairs*

        return ans\_count

obj=Solution()

print(obj.countPairs([1,2,2,4],[3,4,6,8,8],10))

1. Anagrams

from collections import defaultdict

def anagrams(s1,s2):

    if len(s1) != len(s2):

        return False

    d1, d2 = defaultdict(int), defaultdict(int) *#ket,value = letter,occurence*

    for i in range(len(s1)):

        d1[s1[i]] +=1

        d2[s2[i]] +=1

    for i in d1:

        if d1[i]!=d2[i]:

            return False

    return True

print(anagrams("algorithm","logarithm"))

1. Pair sum divisible by 5

count=0

a= [1,121,2,43,534,322423411,5144,19,5,10]

d = defaultdict(int)

*#defining a hash function*

*#input value = num*

*#hash value = num%5*

def hash(num):

    return num%5

*#if num1 gives reminder 4 and num2 gives reminder 1 then num1+num2 will give reminder 0*

*#for reminder 0 count all possible combinations*

for i in a:

    d[hash(i)]+=1

count = d[1]\*d[4] + d[2]\*d[3] + d[0]\*(d[0]-1)//2

print(count)

1. Character occurrences in string

def count\_occurances(string,char):

    if len(string)==0:                             *#base case*

        return 0

    if string[0]==char:

        return 1 + count\_occurances(string[1:],char)  *#self work,recursive subproblem*

    else:

        return count\_occurances(string[1:],char)    *#self work,recursive subproblem*

print(count\_occurances("python application",'p'))

1. Sum of digits of a number

def sum\_digits(num):

    if num<10:                                  *#base case*

        return num

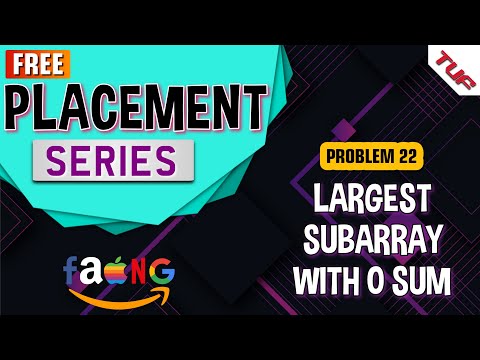
    return num%10 + sum\_digits(num//10)         *#self work , recursive case*

print(sum\_digits(101249))

## **LEVEL 2:**

1. Longest subarray with zero sum

Explanation: The code maintains a cumulative sum (curr\_sum) while iterating through the array. It uses a hash set (sum\_map) to store the cumulative sum as the key and its index as the value. If the current sum is zero, it means there is a subarray starting from index 0 with a sum of zero. If the current sum is already present in the hash set, it means there is a subarray between the indices sum\_map[curr\_sum] and i (inclusive) with a sum of zero. The length of this subarray is calculated and compared with the maximum length. Finally, the maximum length is returned as the result.

[](https://www.youtube.com/watch?v=xmguZ6GbatA)

from collections import defaultdict

def longest\_subarray\_with\_zero\_sum(nums):

*# Stores the cumulative sum as the key and its index as the value*

    sum\_map = defaultdict(int)

    max\_len = 0

    curr\_sum = 0

    for i, num in enumerate(nums):

        curr\_sum += num

        if curr\_sum!=0 and curr\_sum not in sum\_map:

            sum\_map[curr\_sum] = i

        else:

            max\_len = max(max\_len,i-sum\_map[curr\_sum])

    return max\_len

a = [1,-1,3,2,-2,-8,1,7,10,23]

print(longest\_subarray\_with\_zero\_sum(a))

1. #temp

def subsets(i,n,array,s):     *#s= output so far*

    if i==n:

        print('['+s+']')

        return

    subsets(i+1,n,array,s+array[i])

    subsets(i+1,n,array,s)

array=["A","B","C"]

subsets(0,len(array),array,"")

1. #temp

def binary\_strings(i,n,s,flag):

    if i==n:

        print(s)

    else:

        if flag==1:

            binary\_strings(i+1,n,s+"0",0)

        else:

            binary\_strings(i+1,n,s+"0",0)

            binary\_strings(i+1,n,s+"1",1)

binary\_strings(0,4,"",0)

def paths(i,j,m,n,s,l):

    if i==m:

        print(s+"D"\*(l-len(s)))

        return 1

    elif j==n:

        print(s+"R"\*(l-len(s)))

        return 1

    else:

        sub1 =  paths(i+1,j,m,n,s+"R",l)

        sub2 =  paths(i,j+1,m,n,s+"D",l)

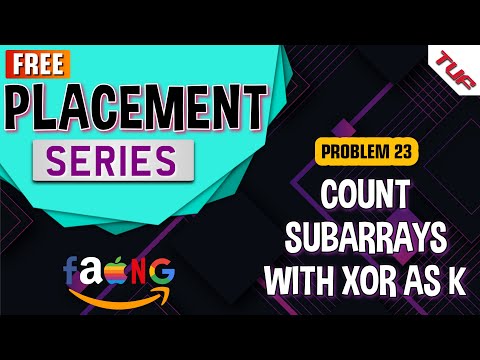
        return sub1+sub2

print(paths(1,1,2,3,"",3))

## **LEVEL 3:**

1. Count of subarrays with xor m

Explanation: The code uses a prefix XOR approach to calculate the XOR value of subarrays. It maintains a prefix XOR variable (prefix\_xor) and a hash map (xor\_count) to store the count of prefix XOR values encountered so far.The array is iterated, the prefix XOR is updated by XOR-ing it with the current number. If the XOR of the current prefix XOR and m exists in the hash map, it means there are subarrays with the target XOR value. The count of such subarrays is added to the count variable. Finally, the total count of subarrays is returned as the result.

[](https://www.youtube.com/watch?v=lO9R5CaGRPY)

from collections import defaultdict

*#Count of subarrays with xor value m*

def count\_subarray(a,m):

    d= defaultdict(int)  *#key,value = prefix\_xor , occurance*

    prefix\_xor= 0

    count =0

    for i in a:

        prefix\_xor = prefix\_xor^i

        if(prefix\_xor==m):                     *#y^m= x ,y=x^m*

            count+=1

        if prefix\_xor^m in d:

            count+= d[prefix\_xor^m]

        d[prefix\_xor] +=1

    return count

a=[4,2,2,6,4]

m = 6

print(count\_subarray(a,m))