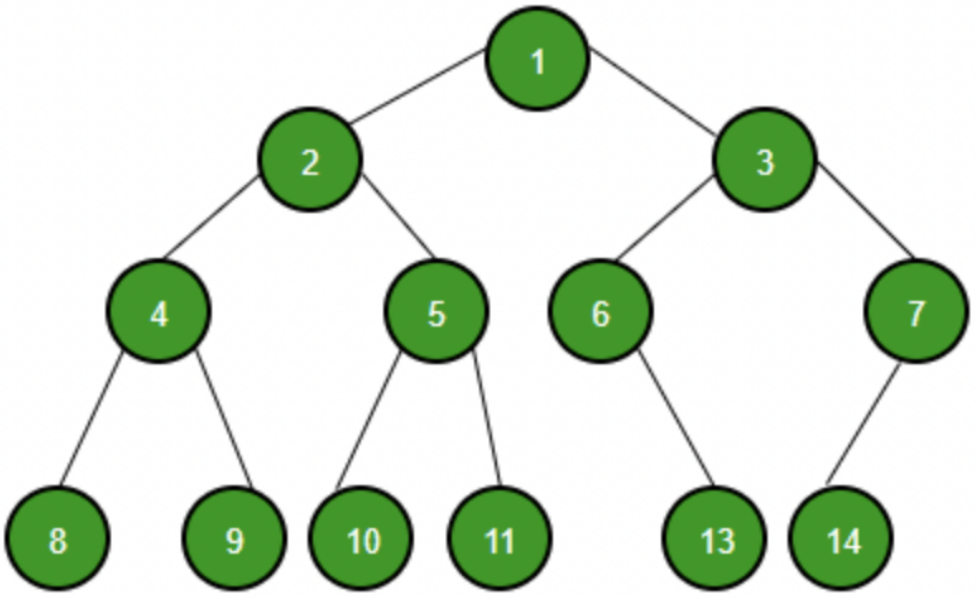
Binary Trees:

A *Tree* is a non-linear data structure where each node is connected to a number of nodes with the help of pointers or references.

A *Binary Tree* is an application of a *Tree* where each node will have at most two child nodes.



- **Root**: The root of a tree is the first node of the tree. In the above image, the root node is node 1.
- **Edge**: An edge is a link connecting any two nodes in the tree. For example, in the above image, there is an edge between nodes **3** and **6**.
- **Siblings**: The child nodes of the same parent are called siblings. That is, the nodes with the same parent are called siblings. In the above tree, nodes *4 and 5* are siblings.
- **Leaf Node**: A node is said to be the leaf node if it has no children. In the above tree, nodes *8, 9, 10, 11, 13, and 14* are leaf nodes.

- **Height of a Tree**: The height of a tree is defined as the total number of levels in the tree. The above tree is of height **4**.

Full Binary Tree/Complete Binary Tree/Perfect Binary Tree: Read from the course material [IMP]

Implementation:

```
class Node {
int data;
      Node *left;
      Node *right;
}
```

Tree Traversals:

Unlike linear data structures (Array, Linked List, Queues, Stacks, etc.), which have only one logical way to traverse them, trees can be traversed in different ways.

Preorder Traversal: In preorder traversal, a node is processed before processing any of the nodes in its subtree.

```
Algorithm Preorder(tree)
   1. Visit the root.
   2. Traverse the left subtree, i.e.,
      call Preorder(left-subtree)
   3. Traverse the right subtree, i.e.,
      call Preorder(right-subtree)
```

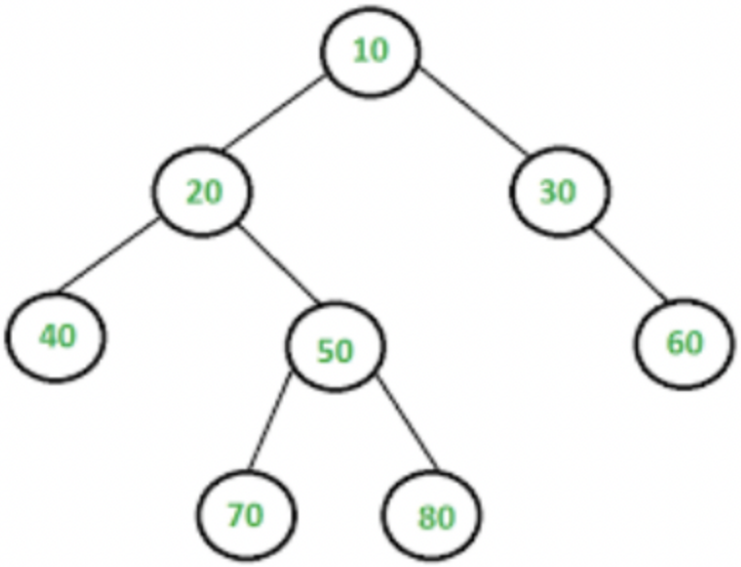
Postorder Traversal: In post order traversal, a node is processed after processing all the nodes in its subtrees.

```
Algorithm Postorder(tree)
   1. Traverse the left subtree, i.e.,
      call Postorder(left-subtree)
   2. Traverse the right subtree, i.e.,
      call Postorder(right-subtree)
   3. Visit the root.
```

Inorder Traversal: In Inorder traversal, a node is processed after processing all the nodes in its left subtree. The right subtree of the node is processed after processing the node itself.

```
Algorithm Inorder(tree)
   1. Traverse the left subtree, i.e.,
      call Inorder(left->subtree)
   2. Visit the root.
   3. Traverse the right subtree, i.e.,
      call Inorder(right->subtree)
```

Level order Traversal:
Traversing each node of the binary tree, level-by-level.



Level order: 10, 20, 30, 40, 50, 60, 70, 80

[IMP: Discuss how it can be used to find the left-view or the right-view of a binary tree].

Height of a Binary Tree:

Given a binary tree, find its height.

Example 1:

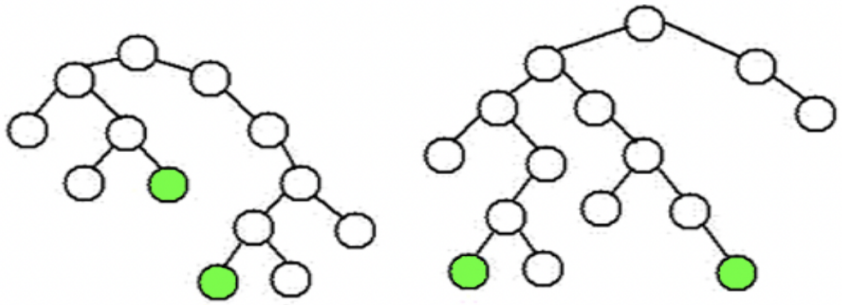
```
Input:
     1
    /  \
   2    3
Output: 2
```

Example 2:

```
Input:
  2
   \
    1
   /
 3
Output: 3
```

Diameter of a Binary Tree:

The diameter of a tree (sometimes called the width) is the number of nodes on the longest path between two end nodes. The diagram below shows two trees each with diameter nine, the leaves that form the ends of the longest path are shaded (note that there is more than one path in each tree of length nine, but no path longer than nine nodes).



Diameter, 9 nodes, through root

Diameter, 9 nodes, NOT through root

Example 1:

```
Input:
       1
     /  \
    2    3
Output: 3
```

Example 2:

```
Input:
         10
        /   \
      20    30
    /   \
   40   60
Output: 4
```

Discuss 3 solutions:

- Brute force
- Precompute heights
- Most optimal: Modify *height* function