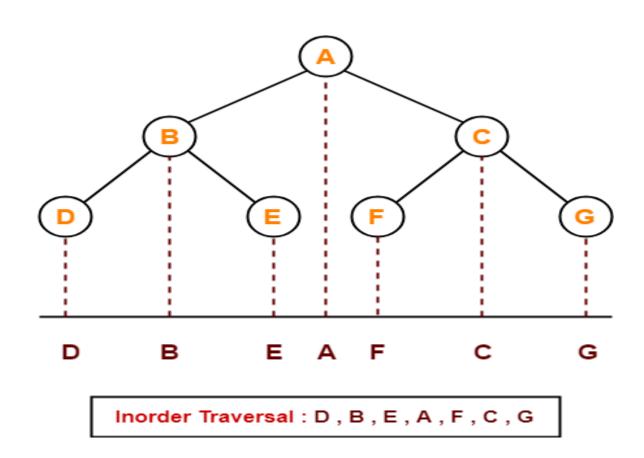
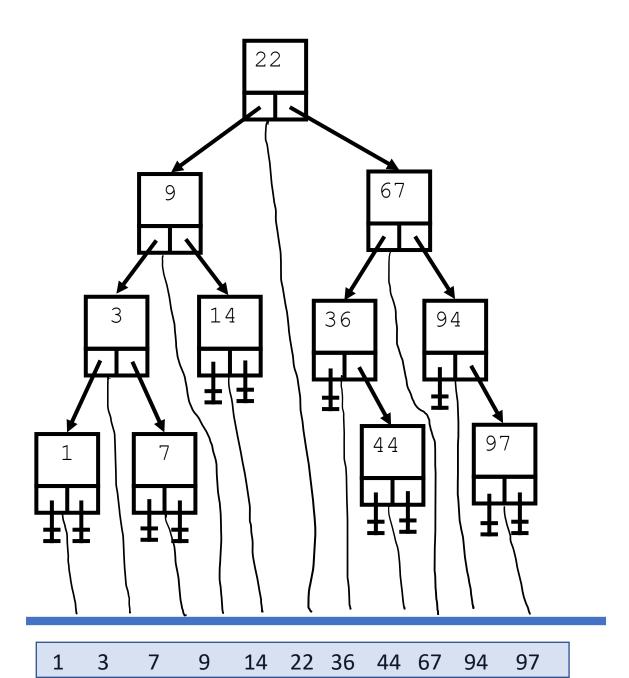
## Miscellaneous Topic

#### In-order Traversal Shortcut Method

Keep a plane mirror horizontally at the bottom of the tree and take the projection of all the nodes.





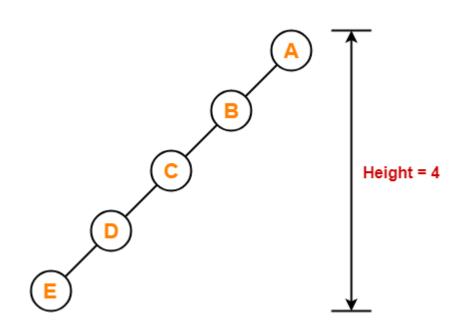
#### Result from original method

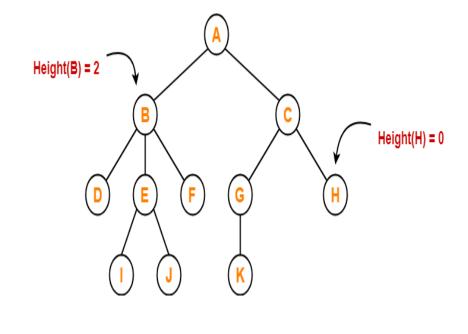
Output: 1 3 7 9 14 22 36 44 67 94 97

Result from shortcut method

#### Minimum number of nodes in a binary tree of height H = H + 1

To construct a binary tree of height = 4, we need at least 4 + 1 = 5 nodes.





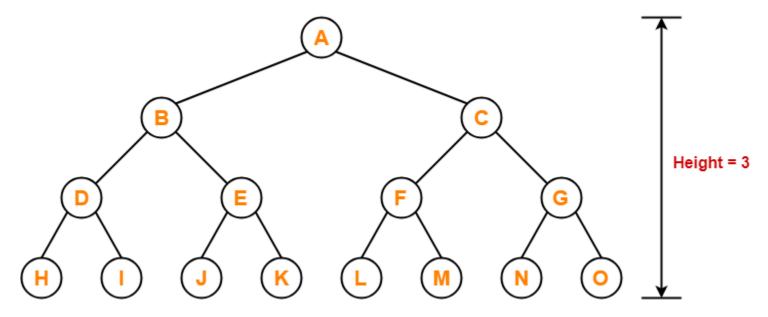
#### Maximum number of nodes in a binary tree of height H = $2^{H+1} - 1$

Maximum number of nodes in a binary tree of height 3

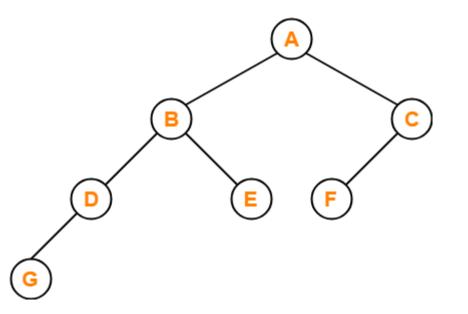
$$= 2^{3+1} - 1$$

$$= 16 - 1$$

= 15 nodes



# Total Number of leaf nodes in a Binary Tree = Total Number of nodes with 2 children + 1

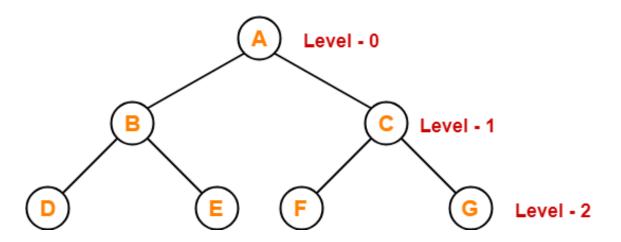


Here,

- •Number of leaf nodes = 3
- •Number of nodes with 2 children = 2

Clearly, number of leaf nodes is one greater than number of nodes with 2 children.

This verifies the above relation.



Maximum number of nodes at any level 'L' in a binary tree
= 2<sup>L</sup>

Maximum number of nodes at level-2 in a binary tree

 $= 2^2$ 

= 4

Thus, in a binary tree, maximum number of nodes that can be present at level-2 = 4.