# Data Structures

# Binary Tree Types

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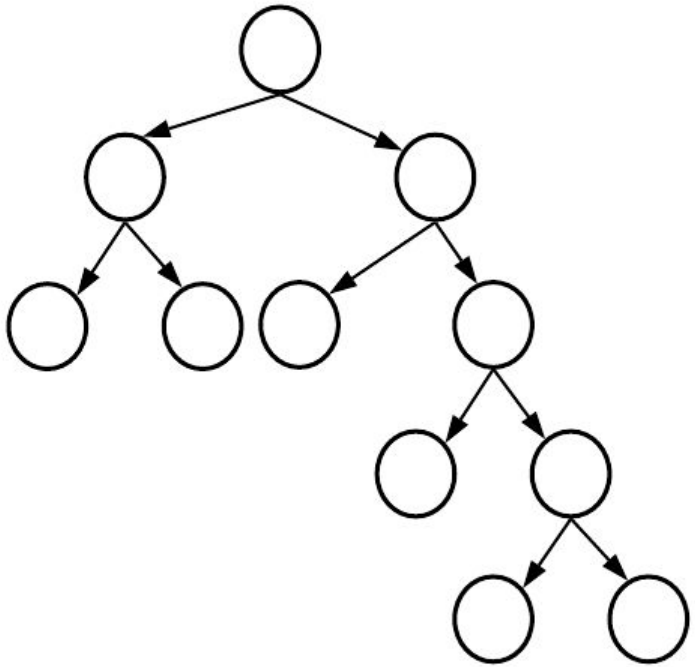
# Full (or strict) Binary Tree

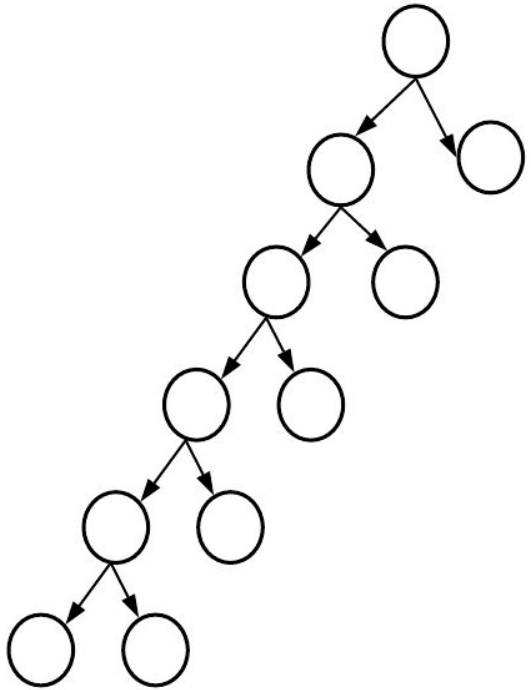
- Condition: Every node has 0 or 2 children
  - Internal node (non-leaf) a node with 1+ child
  - N - leaf_nodes
- In **full** tree, always
  Leaf_nodes = Internal_nodes + 1
- The general version is called full **k-ary tree**
  - Each node has either 0 or exactly k children



# Full (or strict) Binary Tree

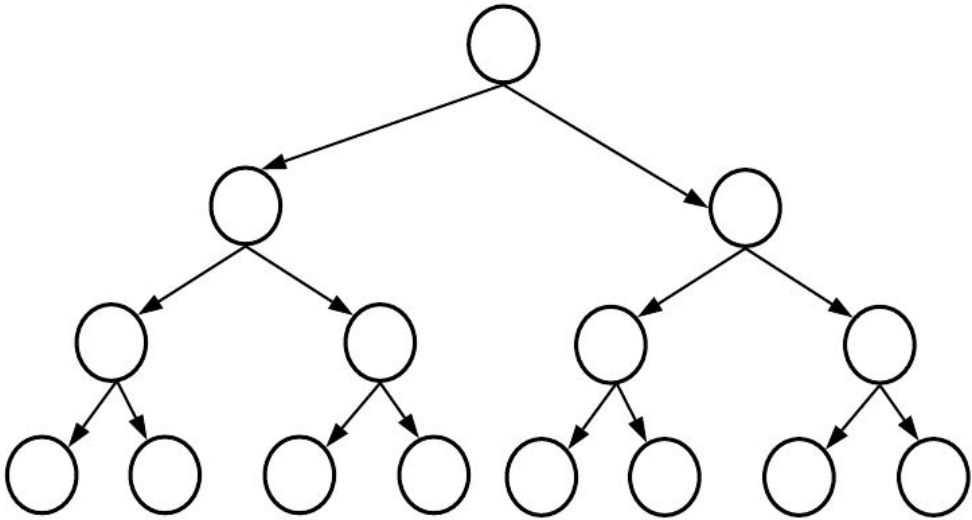
- Given height h, the min # of nodes in a full tree is: **2*h+1**
- Can you create such a tree for h = 5?
- Take 5 minutes

  Just put the minimum number of nodes per level, which is 2, except root is 1



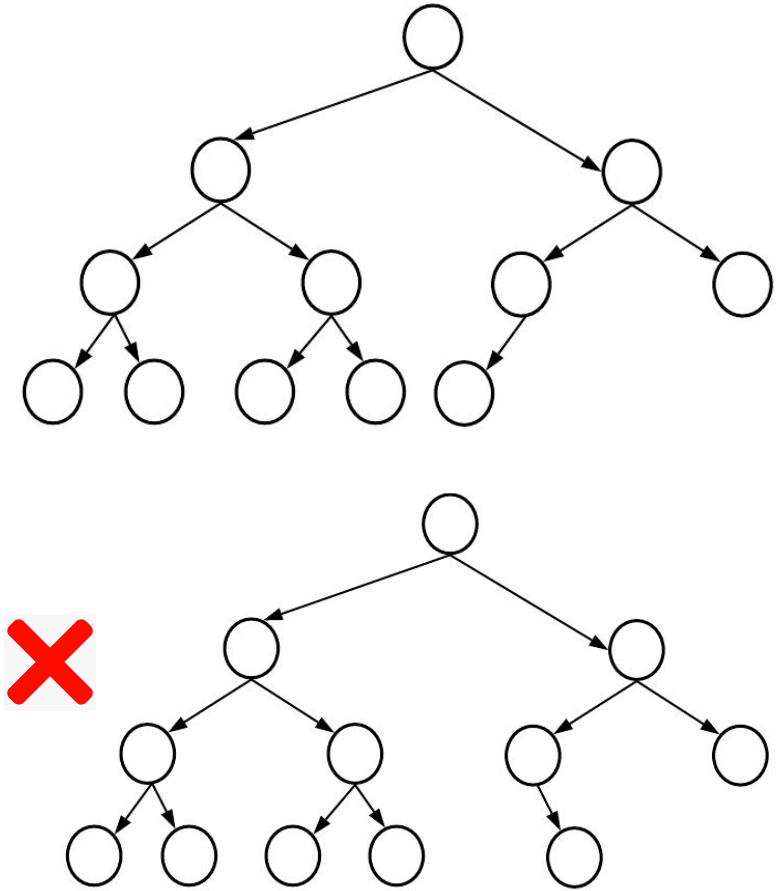
# Perfect Binary Tree

- 2 conditions
  - All leaf nodes have the **same level**
  - All other nodes have **2 children**
- This tree has 4 levels
  - All leaf nodes at 4th level
  - First 3 levels has 2 children
- 4 **complete** levels
  - A complete level: **all possible** nodes **exist**
- Recall
  - Levels = 4 but Height = 3



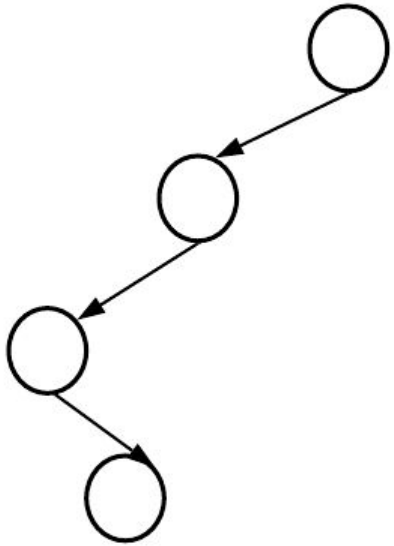
# Complete Binary Tree

- All levels are **complete**
  - **except possibly** the last one, which is filled from the **left**.
- Top tree
  - 4 levels
  - First 3 are complete
  - Last one has left nodes
- Bottom tree: NOT complete
  - Has a right node before a left one
- **Perfect** Binary Tree is a **complete** tree / full tree



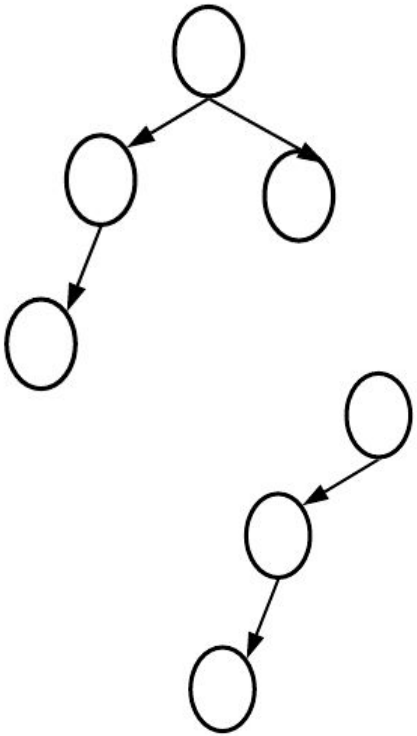
# A degenerate tree

- Each node has 1 child
- Given N nodes, we can construct a tree with **largest depth** of N using a degenerate tree
- But what about the **smallest depth**?



# A balanced binary tree

- Degenerate subtrees make our code very slow.
- In a balanced tree, we try to make the height as small as possible ( ~logn)
- To achieve that, we build a balanced binary tree which satisfies:
  - Difference between **heights** of left subtree and right subtree is not more than 1.
    - E.g. heights of (left, right): (6, 6) or (6, 5) or (5, 6)
  - Left subtree is balanced
  - Right subtree is balanced
- Top tree is balanced, below is not
- Complete/perfect trees are balanced



"Acquire knowledge and impart it to the people."

"Seek knowledge from the Cradle to the Grave."