

# CSE 250 Recitation

Nov 4~5: Binary Trees

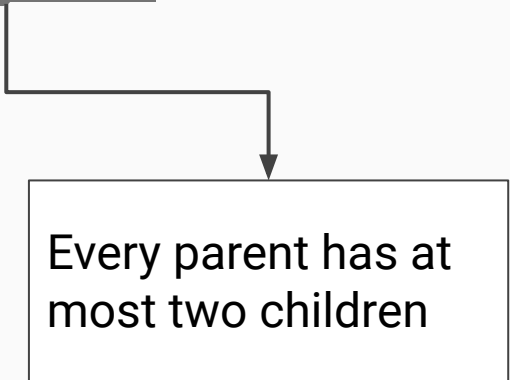


# Heaps

A heap is a **partially ordered complete binary tree**

# Heaps

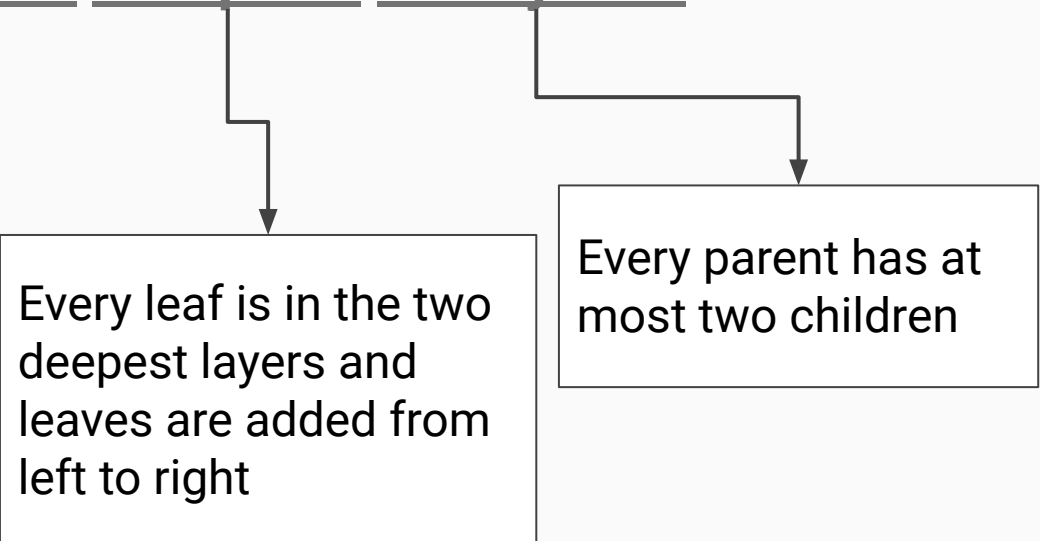
A heap is a partially ordered complete binary tree



Every parent has at most two children

# Heaps

A heap is a partially ordered complete binary tree



Every leaf is in the two deepest layers and leaves are added from left to right

Every parent has at most two children

# Heaps

A heap is a partially ordered complete binary tree

You can infer the order between parents and children, but not between siblings

Min Heap: parent  $\leq$  children

Max Heap: parent  $\geq$  children

Every leaf is in the two deepest layers and leaves are added from left to right

Every parent has at most two children

# Binary Search Trees

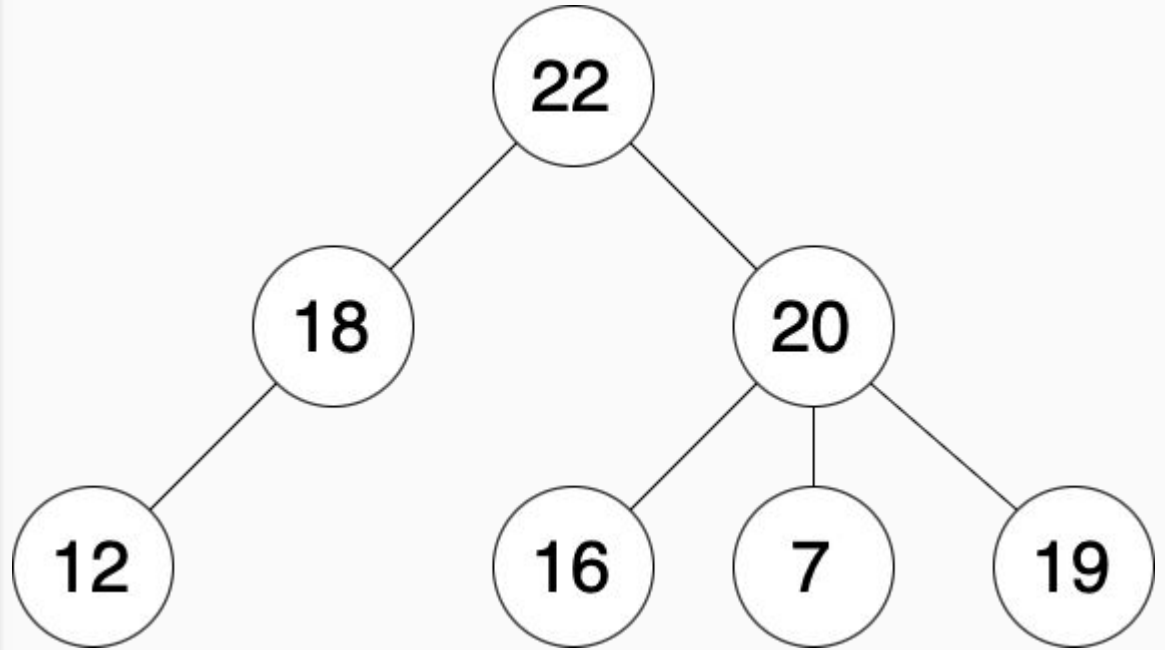
A binary search tree is a **binary tree** where:

- Every node in the right subtree of a node are greater than that node
- Every node in the left subtree of a node is less than that node

*These two conditions mean that each node partitions the binary search tree into a lesser subtree and greater subtree*

# Binary Tree Examples

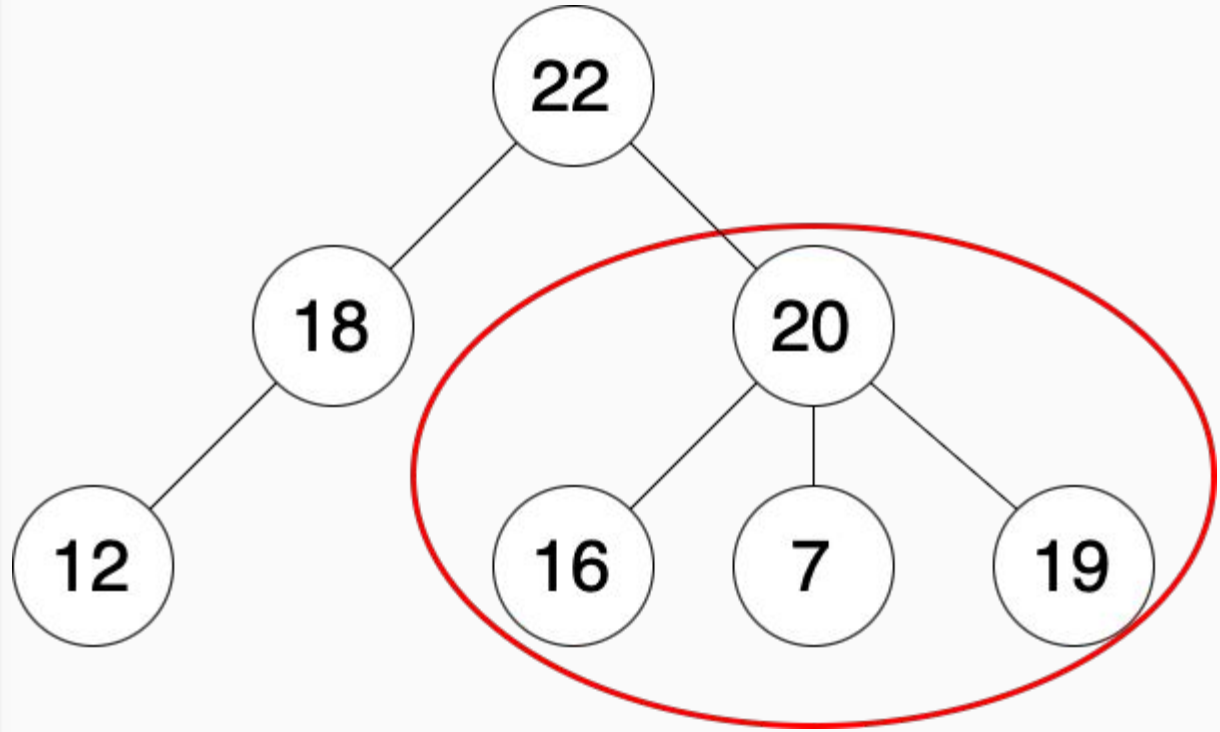
Is this a binary tree?



# Binary Tree Examples

Is this a binary tree?

NO! Node 20 has  $> 2$   
children

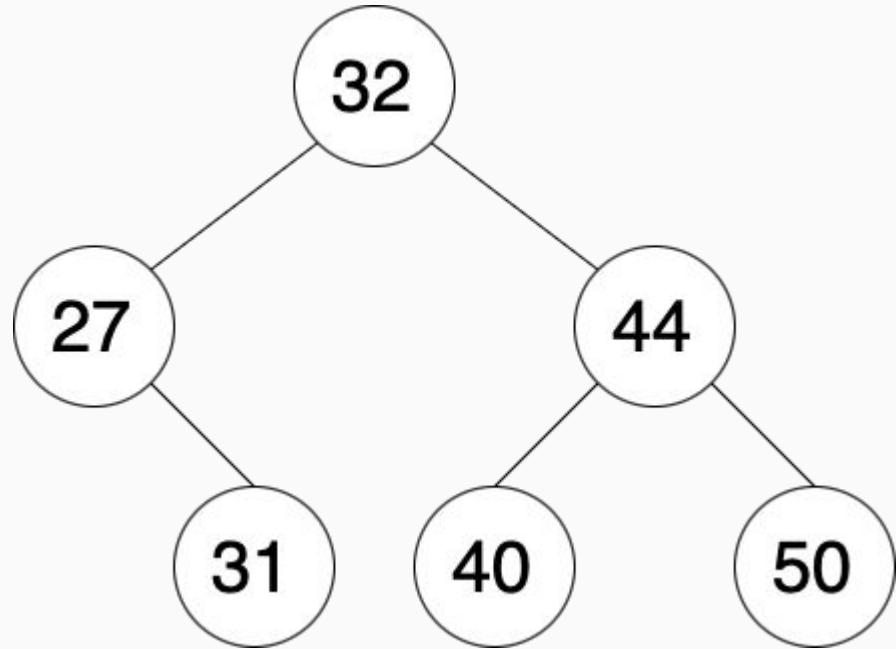




## Binary Tree Examples

Is this a binary tree?

Could this be a heap,  
binary search tree, or  
both?



# Binary Tree Examples

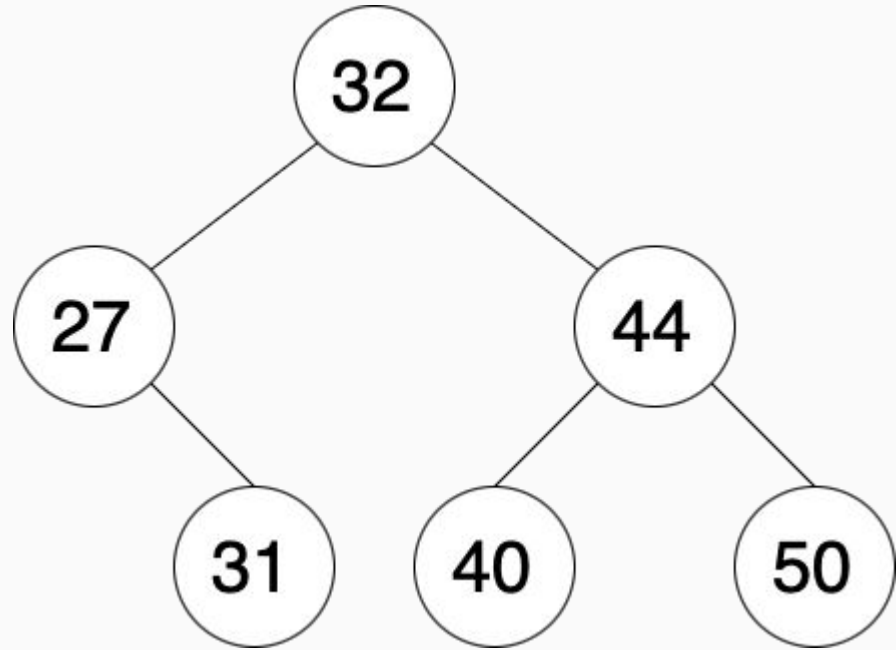
Is this a binary tree?

YES!

Could this be a heap,  
binary search tree, or  
both?

BST (every node  
partitions its subtrees)

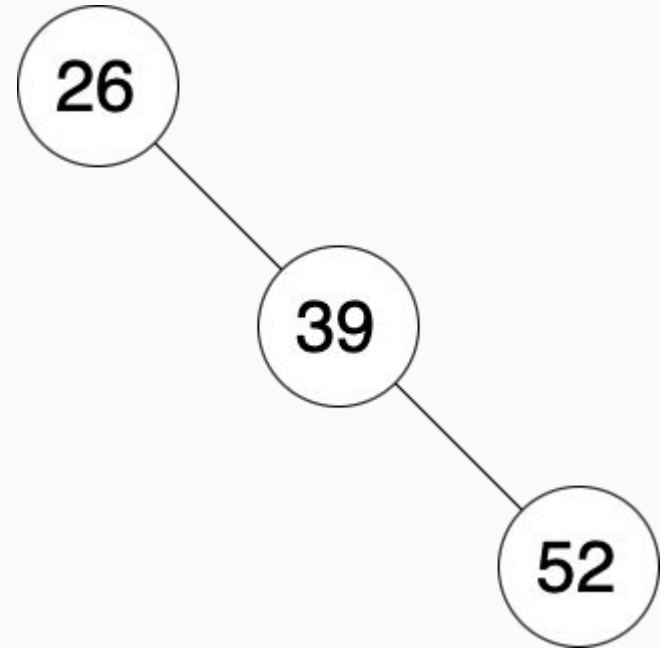
Not a heap (not complete,  
incorrect ordering)



## Binary Tree Examples

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# Binary Tree Examples

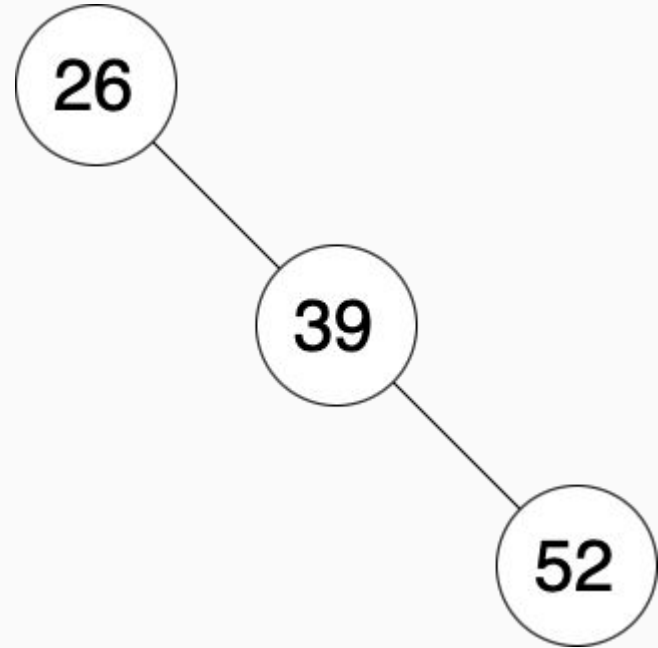
Is this a binary tree?

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Could this be a heap,  
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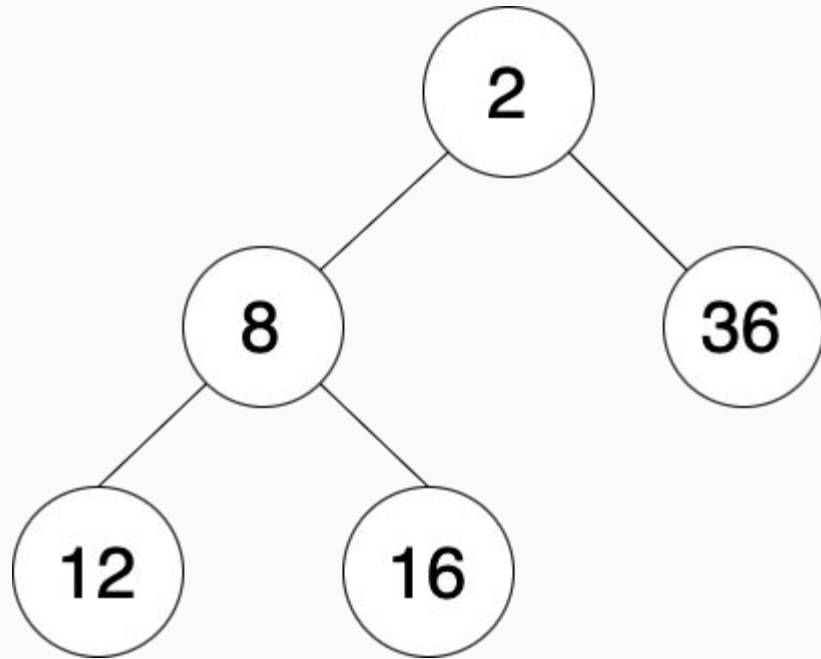
Not a heap (not complete)



## Binary Tree Examples

Is this a binary tree?

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# Binary Tree Examples

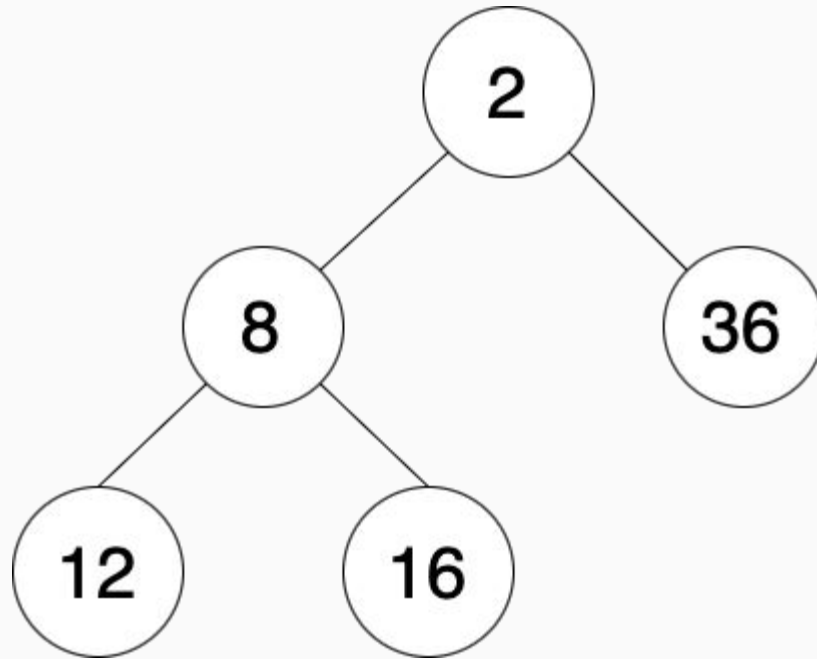
Is this a binary tree?

YES!

Could this be a heap,  
binary search tree, or  
both?

Min Heap (complete and  
every parent is  $\leq$  its  
children)

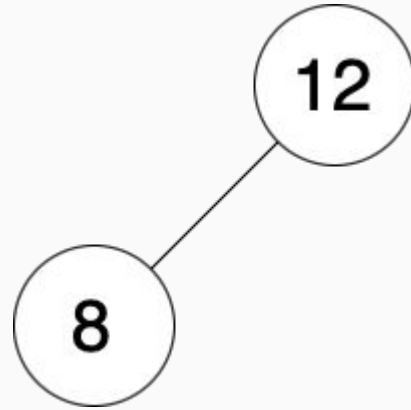
Not a BST (every left child  
is greater than its parent)



# Binary Tree Examples

Is this a binary tree?

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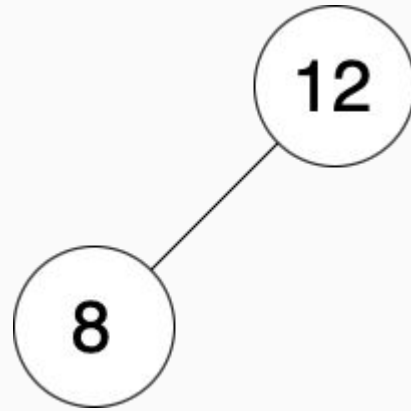
## Binary Tree Examples

Is this a binary tree?

YES!

Could this be a heap,  
binary search tree, or  
both?

Both a BST and Max Heap!





# Exercise

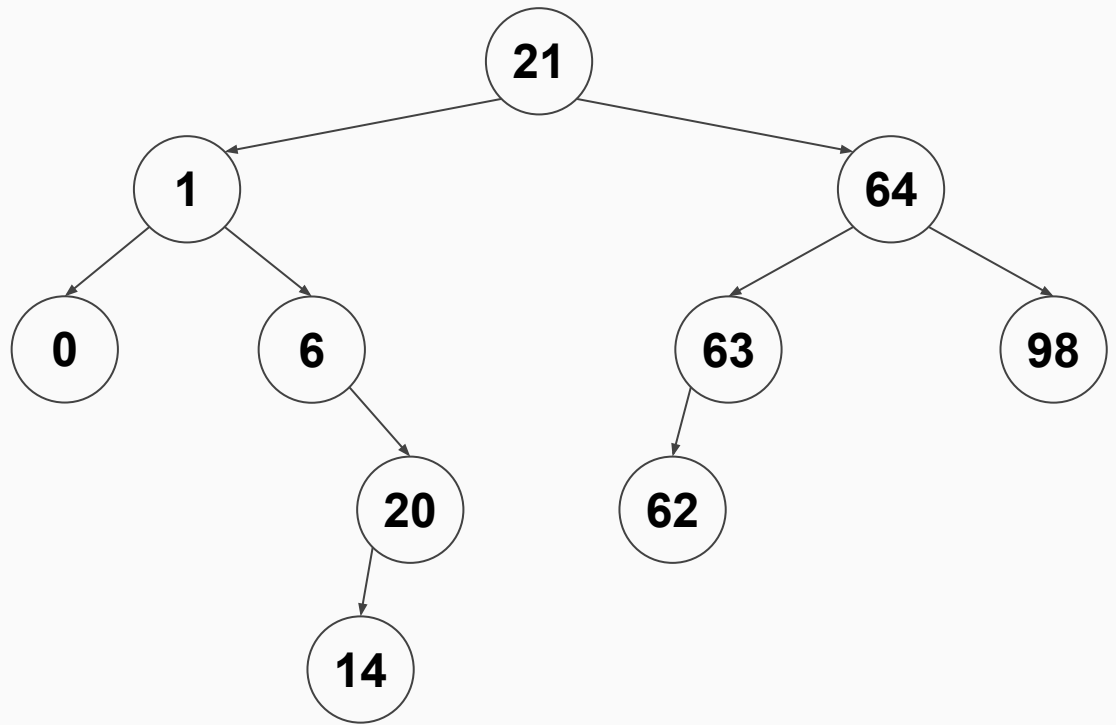
Create a valid BST containing the numbers 1-7 that:

- Has a depth of 2
- Has a depth of 3
- Has a depth of 4
- Has a depth of 5
- Has a depth of 6

What insertion order leads to the minimum depth? The maximum depth?

## Balanced Trees

Does this tree satisfy  
AVL tree constraints?

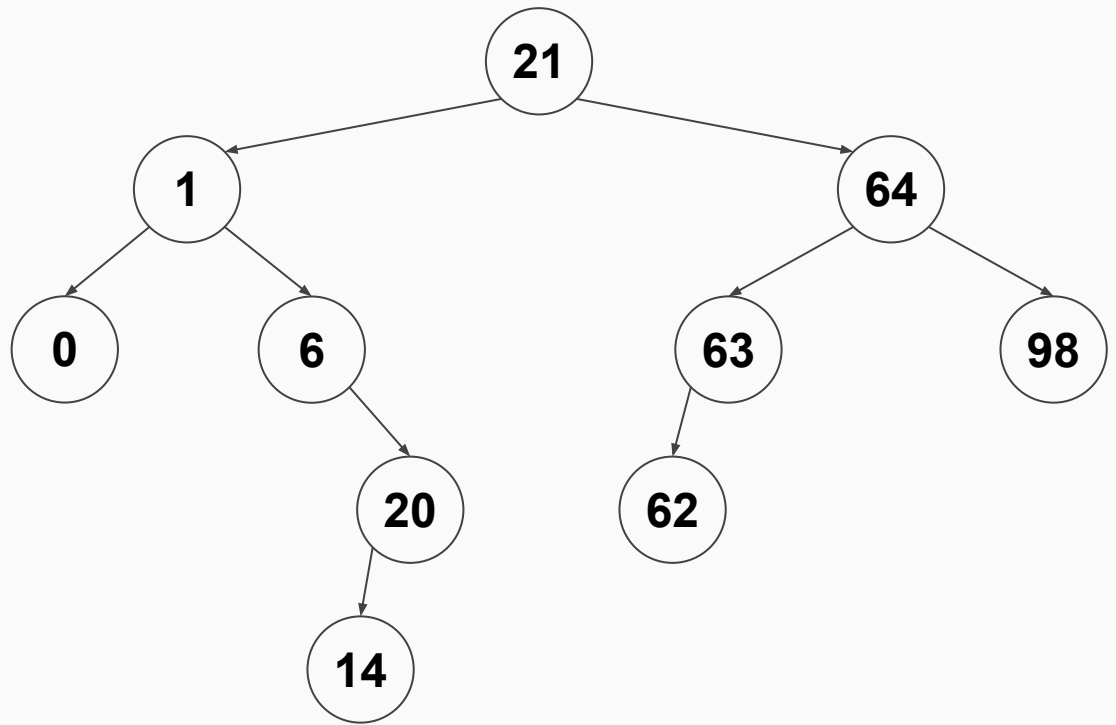


## Balanced Trees

Does this tree satisfy  
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**NO!**

What is the deepest  
node that breaks the  
AVL property?

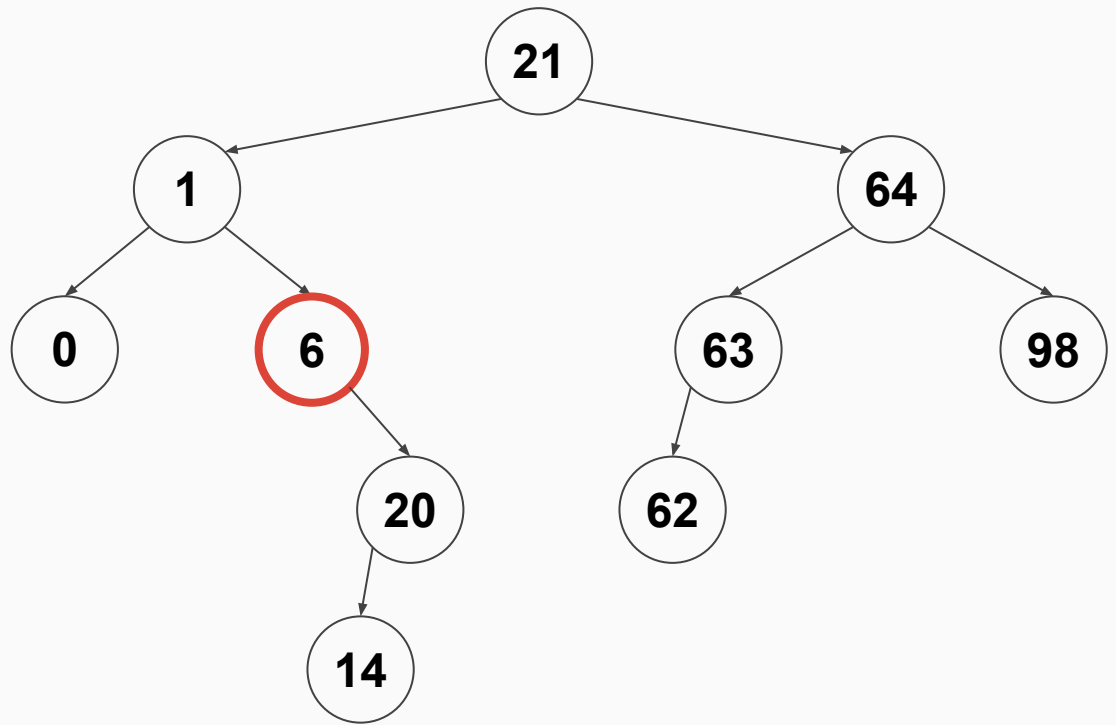


## Balanced Trees

Does this tree satisfy the AVL-tree property? **NO!**

What is the lowest node in the tree that breaks the AVL constraint? **6**

What operations need to be performed to fix the AVL tree constraint?

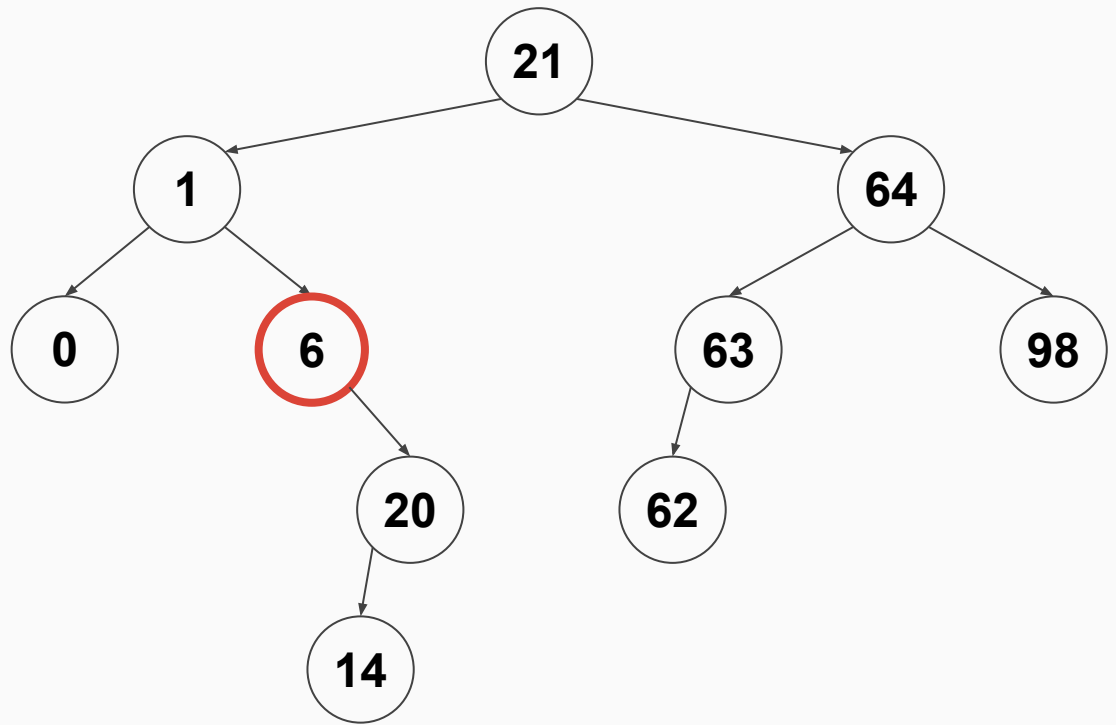


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Does this tree satisfy the AVL-tree property? **NO!**

What is the lowest node in the tree that breaks the AVL constraint? **6**

What operations need to be performed to fix the AVL tree constraint?  
**(Rotate right around 20, then left around 6)**

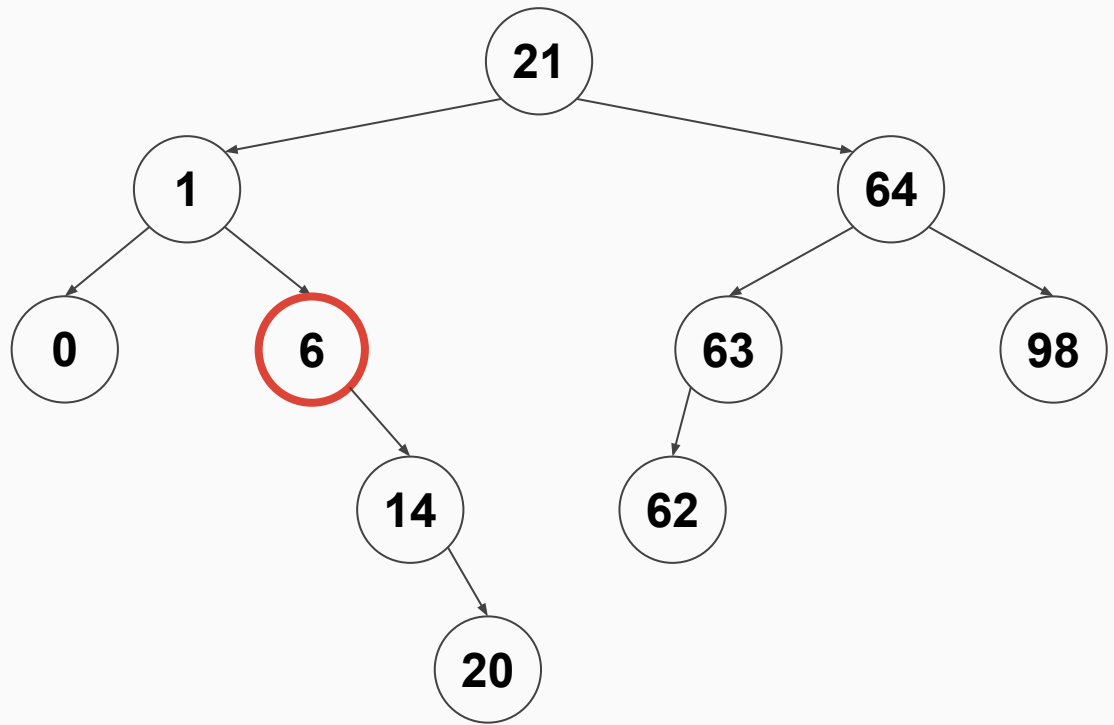


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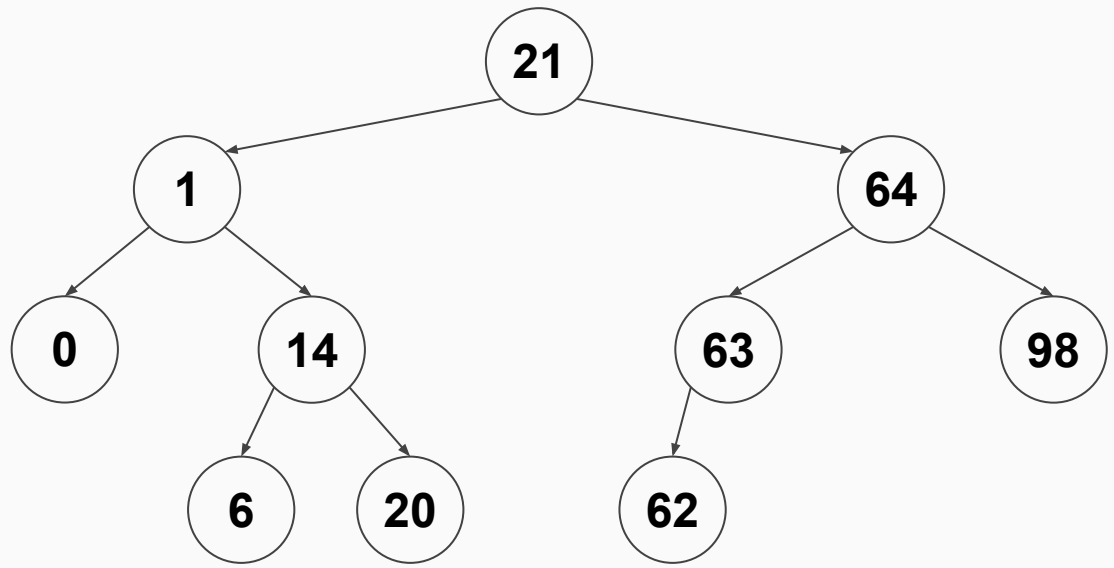


## Balanced Trees

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# Blooket Midterm Review

Review questions on Blooket:

<https://dashboard.blooket.com/set/660b78748e1bd2b64620bd95>