TIP102 | Intermediate Technical Interview Prep

Intermediate Technical Interview Prep Spring 2025 (@ Section 3 | Tuesdays and Thursdays 6PM - 8PM PT)
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Session 2: Binary Trees

Session Overview

Students continue to work with binary trees and are introduced to foundational algorithms for a common subcategory of trees: binary search trees (BSTs). The problems encourage exploring key operations such as inserting and removing nodes, checking tree balance, finding specific nodes, and traversing trees in various orders.

> You can find all resources from today including session slide decks, session recordings, and more on the resources tab

📊 Part 1 : Instructor Led Session

We'll spend the first portion of the synchronous class time in large groups, where the instructor will lead class instruction for 30-45 minutes.

👨‍💻 Part 2: Breakout Session

In breakout sessions, we will explore and collaboratively solve problem sets in small groups. Here, the **collaboration, conversation, and approach** are just as important as “solving the problem” - please engage warmly, clearly, and plentifully in the process!

In breakout rooms you will:

- Screen-share the problem/s, and verbally review them together
- Screen-share an interactive coding environment, and talk through the steps of a solution approach
    - ProTip: - An Integrated Development Environment (IDE) is a fancy name for a tool you could use for shared writing of code - like Replit.com, Collabed.it, CodePen.io, or other - your staff team will specify which tool to use for this class!
- Screen-share an implementation of your proposed solution
- Independently follow-along, or create an implementation, in your own IDE.

Your program leader/s will indicate which code sharing tool/s to use as a group, and will help break down or provide specific scaffolding with the main concepts above.

▶ **Note on Expectations**

🔎 Problem Solving Approach

To build a long-term organized approach to problem solving, we'll start with three main steps. We'll refer to them as **UPI: Understand, Plan, and Implement**.

We'll apply these three steps to most of the problems we'll see in the first half of the course.

We will learn to:

- **Understand** the problem,
- **Plan** a solution step-by-step, and
- **Implement** the solution

▶ Comment on UPI

▶ UPI Example

ℹ️ **Note: Testing your Binary Tree (Printing)**

To keep the amount of starter code manageable, we have chosen not to include a function to print a binary tree as part of each relevant problem statement. You may instead copy the function in the drop-down below `print_tree()` and use it as needed while you complete the problem sets.

▼ Print Binary Tree Function

Accepts the root of a binary tree and prints out the values of each node level by level from left to right. Values of `None` are used to indicate a null child node between non-null children on the same level. Prints `"Empty"` for an empty tree.

```
from collections import deque

# Tree Node class
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def print_tree(root):
    if not root:
        return "Empty"
    result = []
    queue = deque([root])
    while queue:
        node = queue.popleft()
        if node:
            result.append(node.val)
            queue.append(node.left)
            queue.append(node.right)
        else:
            result.append(None)
    while result and result[-1] is None:
        result.pop()
    print(result)
```

Example Usage:

```
"""
          1
        /   \
       2     3
      /     / \
     4     5   6
"""

root = Node(1, Node(2, Node(4)), Node(3, Node(5), Node(6)))

print_tree(root)
print_tree(None)
```

Example Output:

```
[1, 2, 3, 4, None, 5, 6]
'Empty'
```

ℹ️ Note: Testing your Binary Tree (Generating a Tree)

Now that you have practice manually building trees for testing in previous sessions, we are providing a function that builds binary trees based off of a list of values to speed up the testing process. We have chosen not to include this function in the starter code for each problem to keep the length of problems manageable. You may instead copy the function in the drop-down below `build_tree()` and use it as needed while you complete the problem sets.

▼ Build Binary Tree Function

Takes in a list `values` where each element in the list corresponds to a node in the binary tree you would like to build. The values should be in level order (from top to bottom, left to right). Use `None` to indicate a null child between non-null children on the same level.

Some problems may ask you to build a tree where nodes have both keys and values. This function may be used to build trees with just values *and* trees with both keys and values:

- If building a tree with only values, `values` should be given in the form: `[value1, value2, value3, ...]`.
- If building a tree with both keys and values `values` should be given in the form `[(key1, value1), (key2, value2), (key3, value3), ...]`.

Returns the `root` of the binary tree made from `values`.

```
from collections import deque

# Tree Node class
class TreeNode:
  def __init__(self, value, key=None, left=None, right=None):
      self.key = key
      self.val = value
      self.left = left
      self.right = right

def build_tree(values):
  if not values:
      return None

  def get_key_value(item):
      if isinstance(item, tuple):
          return item[0], item[1]
      else:
          return None, item

  key, value = get_key_value(values[0])
  root = TreeNode(value, key)
  queue = deque([root])
  index = 1

  while queue:
      node = queue.popleft()
      if index < len(values) and values[index] is not None:
          left_key, left_value = get_key_value(values[index])
          node.left = TreeNode(left_value, left_key)
          queue.append(node.left)
      index += 1
      if index < len(values) and values[index] is not None:
          right_key, right_value = get_key_value(values[index])
          node.right = TreeNode(right_value, right_key)
          queue.append(node.right)
      index += 1

  return root
```

Example Usage:

```
"""
          1
        /   \
       2     3
      /     / \
     4     5   6
"""

tree_with_just_values = [1, 2, 3, 4, None, 5, 6]
val_tree = build_tree(tree_with_just_values)

"""
          (1, 'A')
          /       \
       (2, 'B')   (3, 'C')
      /           /      \
  (4, 'D')    (5, 'E')   (6, 'F')
"""

tree_with_keys_and_values = [(1, 'A'), (2, 'B'), (3, 'C'), (4, 'D'), None, (5, 'E
key_val_tree = build_tree(tree_with_keys_and_values)

# Using print_tree() function included above
print_tree(val_tree)
print_tree(key_val_tree) # Only values will be printed
```

Example Output:

```
[1, 2, 3, 4, None, 5, 6]
['A', 'B', 'C', 'D', None, 'E', 'F']
```

Breakout Problems Session 2

▸ Standard Problem Set Version 1

▸ Standard Problem Set Version 2

▾ Advanced Problem Set Version 1

Problem 1: Sorting Plants by Rarity

You are going to a plant swap where you can exchange cuttings of your plants for new plants from other plant enthusiasts. You want to bring a mix of cuttings from both common and rare plants in your collection. You track your plant collection in a binary search tree (BST) where each node has a `key` and a `val`. The `val` contains the plant name, and the `key` is an integer representing the plant's rarity. Plants are organized in the BST by their `key`.

To help choose which plants to bring, write a function `sort_plants()` which takes in the BST root `collection` and returns an array of plant nodes as tuples in the form `(key, val)` sorted from least to most rare. Sorted order can be achieved by performing an **inorder traversal** of the BST.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, val, key, left=None, right=None):
        self.key = key      # Plant price
        self.val = val      # Plant name
        self.left = left
        self.right = right


def sort_plants(collection):
    pass
```

Example Usage:

```
"""
         (3, "Monstera")
        /               \
   (1, "Pothos")     (5, "Witchcraft Orchid")
        \                 /
  (2, "Spider Plant")   (4, "Hoya Motoskei")
"""

# Using build_tree() function at the top of page
values = [(3, "Monstera"), (1, "Pothos"), (5, "Witchcraft Orchid"), None, (2, "Spide
collection = build_tree(values)

print(sort_plants(collection))
```

Example Output:

```
[(1, 'Pothos'), (2, 'Spider Plant'), (3, 'Monstera'), (4, 'Hoya Motoskei'), (5, 'Wit
```

▶ 💡 **Hint: Traversing Trees**

Problem 2: Flower Finding

You are looking to buy a new flower plant for your garden. The nursery you visit stores its inventory in a binary search tree (BST) where each node represents a plant in the store. The plants are organized according to their names (`val` s) in alphabetical order in the BST.

Given the root of the binary search tree `inventory` and a target flower `name`, write a function `find_flower()` that returns `True` if the flower is present in the garden and `False` otherwise.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode():
     def __init__(self, value, left=None, right=None):
         self.val = value
         self.left = left
         self.right = right

def find_flower(inventory, name):
    pass
```

Example Usage:

```
"""
         Rose
        /    \
      Lily   Tulip
     /  \       \
  Daisy  Lilac  Violet
"""

# using build_tree() function at top of page
values = ["Rose", "Lily", "Tulip", "Daisy", "Lilac", None, "Violet"]
garden = build_tree(values)

print(find_flower(garden, "Lilac"))
print(find_flower(garden, "Sunflower"))
```

Example Output:

```
True
False
```

▶ 💡 **Hint: Binary Search Trees**

Problem 3: Adding a New Plant to the Collection

You have just purchased a new houseplant and are excited to add it to your collection! Your collection is meticulously organized using a Binary Search Tree (BST) where each node in the tree represents a houseplant in your collection, and houseplants are organized alphabetically by name (`val`).

Given the root of your BST `collection` and a new houseplant `name`, insert a new node with value `name` into your collection. Return the root of your updated collection. If another plant with `name` already exists in the tree, add the new node in the existing node's right subtree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def add_plant(collection, name):
    pass
```

Example Usage:

```
"""
            Money Tree
        /               \
Fiddle Leaf Fig    Snake Plant
"""

# Using build_tree() function at the top of page
values = ["Money Tree", "Fiddle Leaf Fig", "Snake Plant"]
collection = build_tree(values)

# Using print_tree() function at the top of page
print_tree(add_plant(collection, "Aloe"))
```

Example Output:

```
['Money Tree', 'Fiddle Leaf Fig', 'Snake Plant', 'Aloe']

Explanation:
Tree should have the following structure:
           Money Tree
        /               \
 Fiddle Leaf Fig   Snake Plant
   /
 Aloe
```

Problem 4: Remove Plant

A plant in your houseplant collection has become infested with aphids, and unfortunately you need to throw it out. Given the root of a BST `collection` where each node represents a plant in your collection, and a plant `name`, remove the plant node with value `name` from the collection. Return the root of the modified collection. Plants are organized alphabetically in the tree by value.

If the node with `name` has two children in the tree, replace it with its **inorder predecessor** (rightmost node in its left subtree). You do not need to maintain a balanced tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def remove_plant(collection, name):
    pass
```

Example Usage:

```
"""
              Money Tree
             /          \
           Hoya         Pilea
             \          /   \
             Ivy    Orchid  ZZ Plant
"""

# Using build_tree() function at the top of page
values = ["Money Tree", "Hoya", "Pilea", None, "Ivy", "Orchid", "ZZ Plant"]
collection = build_tree(values)

# Using print_tree() function at the top of page
print_tree(remove_plant(collection, "Pilea"))
```

Example Output:

```
['Money Tree', 'Hoya', 'Orchid', None, 'Ivy', None, 'ZZ Plant']

Explanation:
The resulting tree structure:
             Money Tree
            /          \
          Hoya        Orchid
             \           \
             Ivy      ZZ Plant
```

▶ 💡 **Hint: Inorder Predecessor**

Problem 5: Find Most Common Plants in Collection

You have a vast plant collection and want to know which plants you own the most of. Given the `root` of a BST with duplicates where each node is a plant in your collection, return a list with the name(s) (`val`) of the most frequently occurring plant(s) in your collection. If multiple plants tie for the most frequently occuring plant, you may return them in any order.

Assume your BST organizes plants alphabetically by name and follows the following rules:

- The left subtree of a node contains only nodes with values **less than or equal** to the node's value
- The right subtree of a node contains only nodes with values **greater than or equal** to the node's value.
- Both the left and right subtrees must also be BSTs.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def find_most_common(root):
    pass
```

Example Usage:

```
"""
    Hoya
      \
      Pothos
      /
    Pothos
"""

# Using build_tree() function at top of page
values = ["Hoya", None, "Pothos", "Pothos"]
collection1 = build_tree(values)

"""
      Hoya
    /      \
  Aloe    Pothos
  /        /
 Aloe   Pothos
"""
values = ["Hoya", "Aloe", "Pothos", "Aloe", None, "Pothos"]
collection2 = build_tree(values)

print(find_most_common(collection1))
print(find_most_common(collection2))
```

Example Output:

```
['Pothos']
['Aloe', 'Pothos']
```

▶ 💡 **Hint: Choosing a Traversal Order**

Problem 6: Split Collection

You've accumulated too many plants, and need to split up your collection. Given the root of a BST `collection` where each node represents a plant in your collection and a value `target`, split the tree into two subtrees where the first subtree has node values that are lexicographically (alphabetically) smaller than or equal to `target` and the second subtree has all nodes that are greater than `target`. It is not necessarily the case that the collection contains a plant (node) with value `target`.

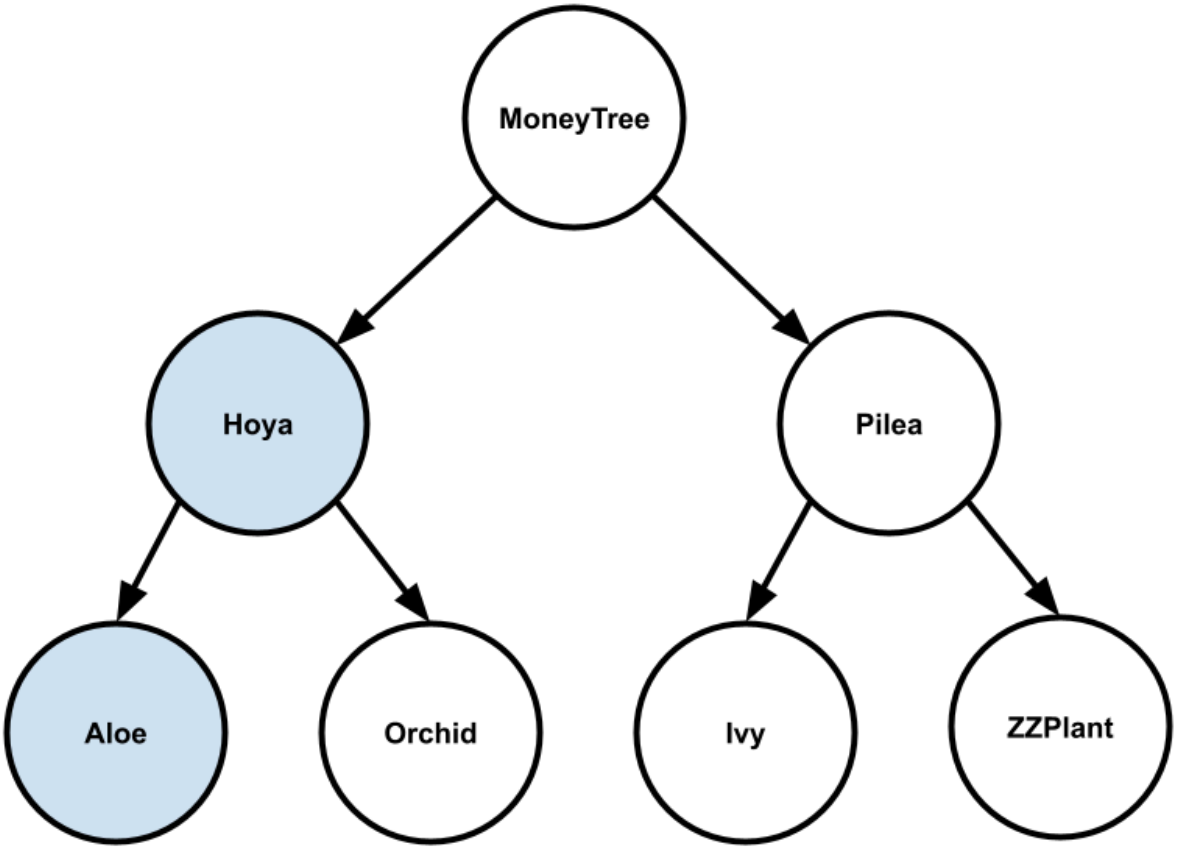
Additionally, most of the structure of the original tree should remain. Formally for any child plant `c` with parent `p` in the original collection, if they are both in the same subtree/subcollection after teh split, then plant `c` should still have the parent `p`.

Return an array of the two root nodes of the two subtrees in order.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def split_collection(collection, target):
    pass
```

Example Usage:



```
"""
              Money Tree
             /          \
           Hoya         Pilea
           /   \         /   \
        Aloe   Ivy    Orchid  ZZ Plant
"""

# Using build_tree() function at the top of the page
values = ["Money Tree", "Hoya", "Pilea", "Aloe", "Ivy", "Orchid", "ZZ Plant"]
collection = build_tree(values)

# Using print_tree() function at the top of the page
left, right = split_collection(collection, "Hoya")
print_tree(left)
print_tree(right)
```

Example Output:

```
['Hoya', 'Aloe']
['Money Tree', 'Ivy', 'Pilea', None, None, 'Orchid', 'ZZ Plant']

Explanation:
Left Subtree:
   Hoya
   /
Aloe

Right Subtree:
    Money Tree
    /       \
   Ivy     Pilea
          /     \
       Orchid  ZZ Plant
```

Problem 7: Pruning Pothos

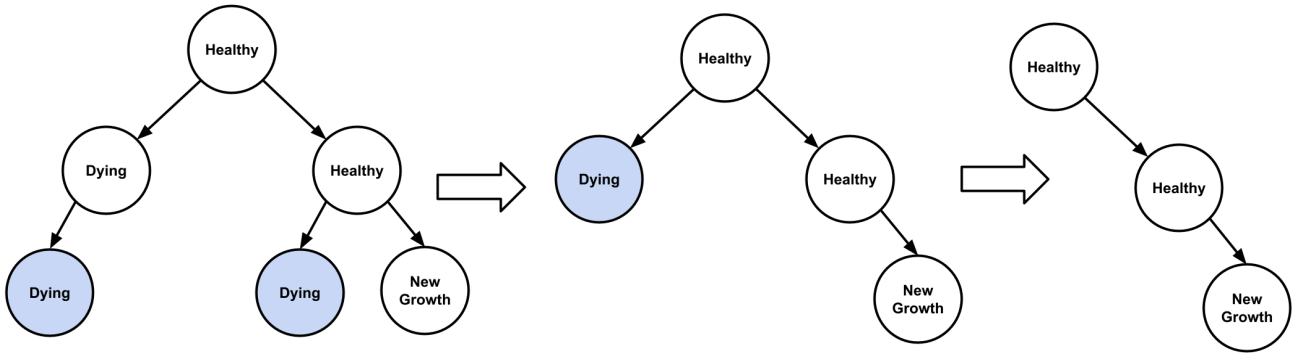
You have a Pothos plant represented as a binary tree, where each node in the tree represents a segment of the plant. Given the `root` of your pothos and a value `target`, you want to delete all **leaf nodes** with value `target`.

Note that once you delete a leaf node with value `target`, if its parent node becomes a leaf node and has the value `target`, it should also be deleted. You should continue deleting nodes until you cannot.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def prune(root, target):
    pass
```

Example Usage 1:

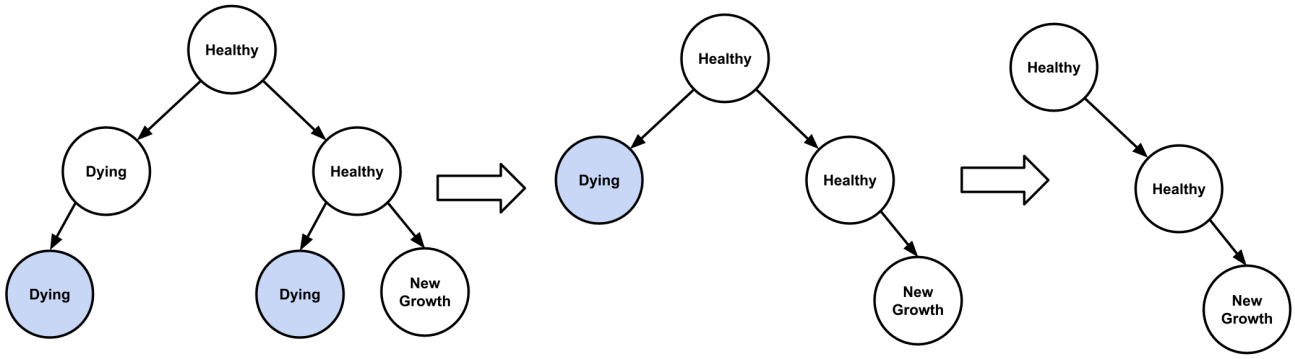



```
"""
         Healthy
        /       \
     Dying    Healthy
     /          /  \
   Dying     Dying  New Growth
"""

# Using build_tree() function at the top of the page
values = ["Healthy", "Dying", "Healthy", "Dying", None, "Dying", "New Growth"]
pothos1 = build_tree(values)

# Using print_tree() function at the top of the page
print_tree(prune(pothos1, "Dying"))
```

Example Output:

```
['Healthy', None, 'Healthy', None, 'New Growth']
Explanation:
Modified Tree:
Healthy
     \
     Healthy
        \
        New Growth
```

Example Usage 2:




```
"""
      Healthy
     /        \
   Aphids     Aphids
   /     \
 Aphids New Growth
"""

values = ["Healthy", "Aphids", "Aphids", "Aphids", "New Growth"]
pothos2 = build_tree(values)

print_tree(prune(pothos2, "Aphids"))
```

Example Output 2:

```
['Healthy', 'Aphids', None, None, 'New Growth']

Explanation:
Modified Tree:
    Healthy
    /
Aphids
    \
    New Growth
```

Problem 8: Find the Lowest Common Ancestor in a Plant Tree Based on Species Names

Given the `root` of a binary tree where each node represents a different plant species, return the value of the lowest common ancestor (LCA) of two given plants in the tree based on their species names. The species names are represented as strings, and the tree is structured according to lexicographical order (alphabetical order). The lowest common ancestor is defined between two species `p` and `q` as the lowest node in the tree that has both `p` and `q` as descendants (where we allow a node to be a descendant of itself).

Assume all plants are a unique species. Note that each `TreeNode` has a reference to its parent node.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

Note: the `build_tree()` function will not work for this problem because of the extra `parent` attribute. You must create your own tree manually for testing.

```
class TreeNode():
    def __init__(self, species, parent=None, left=None, right=None):
        self.val = species
        self.parent = parent # Parent of node
        self.left = left
        self.right = right

def lca(root, p, q):
    pass
```

Example Usage:

```
"""
          fern
        /      \
       /        \
  cactus        rose
   /  \         /   \
bamboo dahlia lily  oak
"""
fern = TreeNode("fern")
cactus = TreeNode("cactus", fern)
rose = TreeNode("rose", fern)
bamboo = TreeNode("bamboo", cactus)
dahlia = TreeNode("dahlia", cactus)
lily = TreeNode("lily", rose)
oak = TreeNode("oak", rose)

fern.left, fern.right = cactus, rose
cactus.left, cactus.right = bamboo, dahlia
rose.left, rose.right = lily, oak

print(lca(fern, "cactus", "rose"))
print(lca(fern, "bamboo", "oak"))
```

Example Output:

```
fern
Example 1 Explanation: The lowest common ancestor of "cactus" and "rose" is "fern" b
is the lowest node in the tree that has both "cactus" and "rose" as descendants.

cactus
Example 2 Explanation: The lowest common ancestor of "bamboo" and "oak" is "fern" be
is the lowest node in the tree that has both "bamboo" and "dahlia" as descendants.
```

▾ Advanced Problem Set Version 2

Problem 1: Sorting Pearls by Size

You have a collection of pearls harvested from a local oyster bed. The pearls are organized by their size in a BST, where each node in the BST represents the size of a pearl.

A function `smallest_to_largest_recursive()` which takes in the BST root `pearls` and returns an array of pearl sizes sorted from smallest to largest has been provided for you.

Implement a new function `smallest_to_largest_iterative()` which provides a iterative solution, taking in the BST root `pearls` and returning an array of pearl sizes sorted from smallest to largest has been provided for you.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time complexity.

```
class Pearl:
    def __init__(self, size, left=None, right=None):
        self.val = size
        self.left = left
        self.right = right

def smallest_to_largest_recursive(pearls):
    sorted_list = []

    def inorder_traversal(node):
        if node:
            inorder_traversal(node.left)
            sorted_list.append(node.val)
            inorder_traversal(node.right)

    inorder_traversal(pearls)
    return sorted_list

def smallest_to_largest_iterative(pearls):
    pass
```

Example Usage:

```
"""
        3
       / \
      /   \
     1     5
      \   / \
       2 4   8
"""

#  Using build_tree() from the top of the page
values = [3, 1, 5, None, 2, 4, 8]
pearls = build_tree(values)

print(smallest_to_largest_recursive(pearls))
print(smallest_to_largest_iterative(pearls))
```

Example Output:

```
[1, 2, 3, 4, 5, 8]
[1, 2, 3, 4, 5, 8]
```

▶ 💡 **Hint: Recursive to Iterative Translations**

Problem 2: Searching Ariel's Treasures

The mermaid princess Ariel is looking for a specific item in the grotto where she collects all the various objects from the human world she finds. Ariel's collection of human treasures is stored in a binary search tree (BST) where each node represents a different item in her collection. The items are organized according to their names (`val` s) in alphabetical order in the BST.

Given the root of the binary search tree `grotto` and a target object `treasure`, write a function `locate_treasure()` that returns `True` if `treasure` is present in the garden and `False` otherwise.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

Hint: Intro to Binary Search Trees

```
class TreeNode():
     def __init__(self, value, left=None, right=None):
         self.val = value
         self.left = left
         self.right = right

def locate_treasure(grotto, treasure):
    pass
```

Example Usage:

```
"""
             Snarfblat
            /         \
        Gadget        Whatzit
       /     \            \
Dinglehopper Gizmo        Whozit
"""

# Using build_tree() function at the top of page
values = ["Snarfblat", "Gadget", "Whatzit", "Dinglehopper", "Gizmo", "Whozit"]
grotto = build_tree(values)

print(locate_treasure(grotto, "Dinglehopper"))
print(locate_treasure(grotto, "Thingamabob"))
```

Example Output:

```
True
False
```

Problem 3: Add New Treasure to Collection

The mermaid princess Ariel and her pal Flounder visited a new shipwreck and found an exciting new human artifact to add to her collection. Ariel's collection of human treasures is stored in a binary search tree (BST) where each node represents a different item in her collection. Items are organized according to their names (`val` s) in alphabetical order in the BST.

Given the root of the binary search tree `grotto` and a string `new_item`, write a function `locate_treasure()` that adds a new node with value `new_item` to the collection and returns the `root` of the modified tree. If a node with value `new_item` already exists within the tree, return the original tree unmodified. You do not need to maintain balance in the tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode():
     def __init__(self, value, left=None, right=None):
         self.val = value
         self.left = left
         self.right = right

def add_treasure(grotto, new_item):
    pass
```

Example Usage:

```
"""
             Snarfblat
            /        \
        Gadget       Whatzit
       /     \           \
Dinglehopper Gizmo       Whozit
"""

# Using build_tree() function at the top of page
values = ["Snarfblat", "Gadget", "Whatzit", "Dinglehopper", "Gizmo", "Whozit"]
grotto = build_tree(values)

# Using print_tree() function included at top of page
print_tree(add_treasure(grotto, "Thingamabob"))
```

Example Output:

```
['Snarfblat', 'Gadget', 'Whatzit', 'Dinglehopper', 'Gizmo', None, 'Whozit']
Explanation:
Updated tree:
               Snarfblat
            /             \
        Gadget             Whatzit
       /     \           /       \
Dinglehopper Gizmo  Thingamabob  Whozit
```

Problem 4: Remove Invasive Species

As a marine ecologist, you are worried about invasive species wreaking havoc on the local ecosystem. Given the root of a BST `ecosystem` where each node represents a species in a marine ecosystem, and an invasive species `name`, remove the species with value `name` from the ecosystem. Return the root of the modified ecosystem. Species are organized alphabetically in the tree by name (`val`).

If the node with `name` has two children in the tree, replace it with its **inorder successor** (leftmost node in its right subtree). You do not need to maintain a balanced tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def remove_species(ecosystem, name):
    pass
```

Example Usage:

```
"""
                Dugong
             /         \
       Brain Coral   Lionfish
              \       /       \
         Clownfish Giant Clam  Seagrass
"""
# Use build_tree() function at top of page
values = ["Dugong", "Brain Coral", "Lionfish", None, "Clownfish", "Giant Clam", "Sea
ecosystem = build_tree(ecosystem)

# Using print_tree() function at top of page
print_tree(remove_species(ecosystem, "Lionfish"))
```

Example Output:

```
['Dugong', 'Brain Coral', 'Giant Clam', None', 'Clownfish', None, 'Seagrass']

Explanation:
The resulting tree structure:
             Dugong
            /      \
      Brain Coral  Giant Clam
              \            \
           Clownfish    Seagrass
```

Problem 5: Minimum Difference in Pearl Size

You are analyzing your collection of pearls stored in a BST where each node represents a pearl with a specific size (`val`). You want to see if you have two pearls of similar size that you can make into a pair of earrings.

Write a function `min_diff_in_pearl_sizes()` that acceps the root of a BST `pearls` , and returns the minimum difference between the sizes of any two different pearls in the collection.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class Pearl:
    def __init__(self, size=0, left=None, right=None):
        self.val = size
        self.left = left
        self.right = right

def min_diff_in_pearl_sizes(pearls):
    pass
```

Example Usage:

```
"""
        4
       / \
      2   6
     / \   \
    1   3   8
"""
# Use build_tree() function at top of page
values = [4, 2, 6, 1, 3, None, 8]
pearls = build_tree(values)

print(min_diff_in_pearl_sizes(pearls))
```

Example Output:

```
1
Example Explanation: The difference between pearl sizes 3 and 4, or 2 and 3
```

Problem 6: Minimum Ocean Depth

You have just finished surveying a new, previously unexplored part of the ocean and want to find the shallowest part. Given the `root` of a binary tree representing this new part of the ocean, return its minimum depth. The minimum depth is the number of nodes along the shortest path from the `root` down to the nearest leaft node.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def find_min_depth(root):
    pass
```

Example Usage:

```
"""
    Shipwreck
   /         \
 Shallows   Reef
           /    \
        Cave    Trench
"""

# Using build_tree() function at top of page
values = ["Shipwreck", "Shallows", "Reef", None, None, "Cave", "Trench"]
ocean = build_tree(values)

print(find_min_depth(ocean))
```

Example Output:

```
2
```

Problem 7: Combining Shipwreck Loot

The mermaid princess Ariel and her friend Flounder have just finished exploring a new shipwreck and have each stored the items they found in a BST. Given the roots of two binary search trees, `root1` and `root2` where each node represents an item found in the shipwreck, return a list containing all the node values from **both trees** in lexographic (alphabetic) order. The tree nodes are organized in lexographic order within each tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def combine_loot(root1, root2):
    pass
```

Example Usage:

```
"""
    Fork                Coin
   /    \              /    \
Coin    Statue     Anchor   Mirror
"""
root1 = TreeNode("Fork", TreeNode("Coin"), TreeNode("Statue"))
root2 = TreeNode("Coin", TreeNode("Anchor"), TreeNode("Mirror"))


"""
    Fork             Necklace
        \              /
       Necklace     Fork
"""
root3 = TreeNode("Fork", None, TreeNode("Necklace"))
root4 = TreeNode("Necklace", TreeNode("Fork"))

print(combine_loot(root1, root2))
print(combine_loot(root3, root4))
```

Example Output:

```
['Anchor', 'Coin', 'Coin', 'Fork', 'Mirror', 'Statue']
['Fork', 'Fork', 'Necklace', 'Necklace']
```

Problem 8: Distributing Sunken Treasure

You and your friends have found a ship wreck full of gold pieces as part of a shipwreck and want to distribute the gold evenly amongst yourselves as efficiently as possible.

You are given the `root` of a binary tree with `n` nodes representing you and your friends where each friend currently has `node.val` coins. There are `n` coins in the whole tree (one for each of you!).

In one move, we may choose two adjacent nodes and move one coin from one node to another. A move may be from parent to child, or from child to parent.

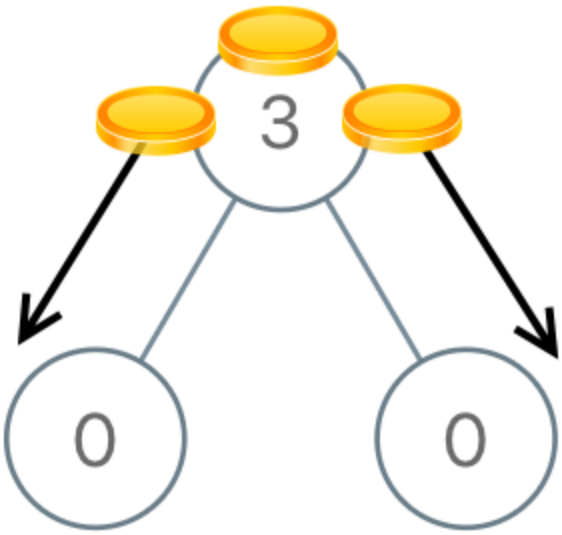
Return the minimum number of moves required to make every node have exactly one coin.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Assume the input tree is balanced when calculating time and space complexity.

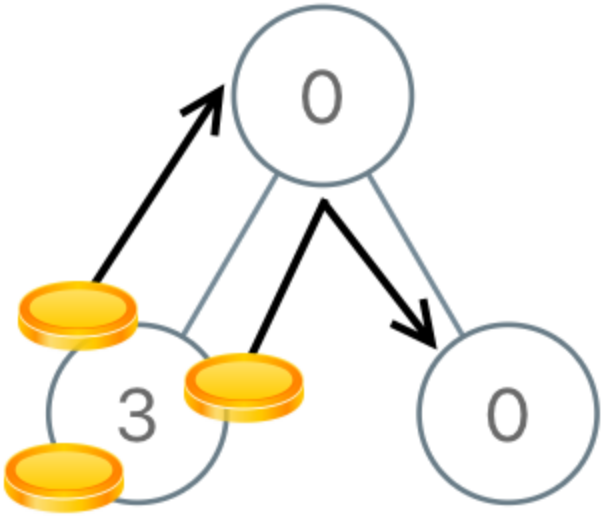
```
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def distribute_coins(root):
    pass
```

Example Usage:

Example 1:



Example 2:



```
"""
    3
   / \
  0   0
"""
root1 = TreeNode(3, TreeNode(0), TreeNode(0))

"""
    0
   / \
  3   0
"""
root2 = TreeNode(0, TreeNode(3), TreeNode(0))

print(distribute_coins(root1))
print(distribute_coins(root2))
```

Example Output:

```
2
Example 1 Explanation: From the root of the tree, we move one coin to its left child
and one coin to its right child.

3
Example 1 Explanation: From the left child of the root, we move two coins to the roo
[taking two moves]. Then, we move one coin from the root of the tree to the right ch
```

▶ 💡 **Hint: Choosing a Traversal Order**

Close Section