TIP102 | Intermediate Technical Interview Prep

Intermediate Technical Interview Prep Summer 2025 (@ Section 1b | Tuesdays and Thursdays 3PM - 5PM PDT)
Personal Member ID#: 126663

Session 1: Binary Trees

Session Overview

Students are introduced to foundational and complex tasks involving binary trees. They will engage in constructing trees, manipulating tree structures, traversing trees, and understanding tree properties through a variety of exercises. This session aims to deepen students' understanding of tree algorithms, enhancing their ability to analyze and implement data structures efficiently.

> 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

We will approach problems using the six steps in the UMPIRE approach.

UMPIRE: Understand, Match, Plan, Implement, Review, Evaluate.

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

We will learn to:

- **Understand** the problem
- **Match** identifies common approaches you've seen/used before
- **Plan** a solution step-by-step, and
- **Implement** the solution
- **Review** your solution
- **Evaluate** your solution's time and space complexity and think critically about the advantages and disadvantages of your chosen approach.

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'
```

Breakout Problems Session 1

▾ Standard Problem Set Version 1

Problem 1: Grafting Apples

You are grafting different varieties of apple onto the same root tree can produce many different varieties of apples! Given the following `TreeNode` class, create the binary tree depicted below. The text representing each node should should be used as the `value`.

The `root`, or topmost node in the tree `TreeNode("Trunk")` has been provided for you.

```
            Trunk
          /       \
      Mcintosh   Granny Smith
      /     \       /     \
    Fuji   Opal   Crab   Gala
```

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

root = TreeNode("Trunk")
```

Example Usage:

```
# Using print_tree() included at the top of this page
print_tree(root)
```

Example Output:

```
['Trunk', 'Mcintosh', 'Granny Smith', 'Fuji', 'Opal', 'Crab', 'Gala']
```

▼ ✨ AI Hint: Binary Trees

Key Skill: Use AI to explain code concepts

This problem requires you to understand binary trees. For a refresher on this topic, check out the Binary Trees section of the Unit 8 Cheatsheet.

If you need more help, try asking an AI tool like ChatGPT or GitHub Copilot to explain the concept of binary trees using a real-world analogy, and any following questions you have.

Once you grasp the idea, you can ask it to show you examples of binary trees in Python.

Problem 2: Calculating Yield

You have a fruit tree represented as a binary tree with exactly three nodes: the `root` and its two children. Given the `root` of the tree, evaluate the amount of fruit your tree will yield this year. The tree has the following form:

- **Leaf nodes** have an integer value.
- The **root** has a string value of either `"+"`, `"-"`, `"*"`, or `"-"`.

The **yield** of a the tree is calculated by applying the mathematical operation to the two children.

Return the result of evaluating the `root` node.

Evaluate the time complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time complexity.

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

def calculate_yield(root):
  pass
```

Example Usage:

```
"""
    +
  /   \
 7     5
"""
apple_tree = TreeNode("+", TreeNode(7), TreeNode(5))

print(calculate_yield(apple_tree))
```

Example Output:

```
12
```

Problem 3: Ivy Cutting

You have a trailing ivy plant represented by a binary tree. You want to take a cutting to start a new plant using the rightmost vine in the plant. Given the `root` of the plant, return a list with the value of each node in the path from the `root` node to the rightmost leaf node.

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

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

def right_vine(root):
  pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""
ivy1 = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

"""
      Root
      /
    Node1
    /
  Leaf1
"""
ivy2 = TreeNode("Root", TreeNode("Node1", TreeNode("Leaf1")))

print(right_vine(ivy1))
print(right_vine(ivy2))
```

Example Output:

```
['Root', 'Node2', 'Leaf3']
['Root']
```

▼ ✨ AI Hint: Balanced Trees

Tree problems will often specify whether or not you can assume a tree is balanced. This can affect the time complexity of your algorithm.

For a quick refresher, check out the Balanced Tree section of the Unit 8 Cheatsheet. If you need more help, try using an AI tool like ChatGPT or GitHub Copilot to show you examples of balanced trees and how they work. For example, you could ask:

"You're an expert computer science tutor. Can you help me understand the concept of a balanced binary tree, using multiple examples and an analogy to real-world objects?"

Problem 4: Ivy Cutting II

If you implemented `right_vine()` iteratively in the previous problem, implement it recursively. If you implemented it recursively, implement it iteratively.

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

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

def right_vine(root):
  pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""
ivy1 = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

"""
      Root
      /
    Node1
    /
  Leaf1
"""
ivy2 = TreeNode("Root", TreeNode("Node1", TreeNode("Leaf1")))

print(right_vine(ivy1))
print(right_vine(ivy2))
```

Example Output:

```
['Root', 'Node2', 'Leaf3']
['Root']
```

Problem 5: Count the Tree Leaves

You've grown an oak tree from a tiny little acorn and it's finally sprouting leaves! Given the `root` of a binary tree representing your oak tree, count the number of leaf nodes in the tree. A leaf node is a node that does not have any children.

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

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

def count_leaves(root):
    pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""

oak1 = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

"""
      Root
      /
    Node1
    /
  Leaf1
"""
oak2 = TreeNode("Root", TreeNode("Node1", TreeNode("Leaf1")))


print(count_leaves(oak1))
print(count_leaves(oak2))
```

Example Output:

```
3
1
```

▼ ✨ AI Hint: Traversing Trees

Key Skill: Use AI to explain code concepts

This problem requires you to traverse a binary tree. For a refresher on this topic, check out the Tree Traversal section of the Unit 8 Cheatsheet.

Still have questions? Try asking an AI tool like ChatGPT or GitHub Copilot to explain the different types of binary tree traversal. You can use the following prompt as a starting point:

"You're an expert computer science tutor. Please explain the different types of binary tree traversal, and show me how they would each work on an example tree."

Hint: Be sure to learn about "preorder", "postorder", and "inorder" traversals!

Problem 6: Pruning Plans

You have a large overgrown Magnolia tree that's in desperate need of some pruning. Before you can prune the tree, you need to do a full survey of the tree to evaluate which sections need to be pruned.

Given the `root` of a binary tree representing the magnolia, return a list of the values of each node using a postorder traversal. In a postorder traversal, you explore the left subtree first, then the right subtree, and finally the root. Postorder traversals are often used when deleting nodes from a tree.

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

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

def survey_tree(root):
    pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""

magnolia = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

print(survey_tree(magnolia))
```

Example Output:

```
["Leaf1", "Node1", "Leaf2", "Leaf3", "Node2", "Root"]
```

Problem 7: Foraging Berries

You've found a wild blueberry bush and want to do some foraging. However, you want to be conscious of the local ecosystem and leave some behind for local wildlife and regeneration. To do so, you plan to only harvest from branches where the number of berries is greater than `threshold`.

Given the `root` of a binary tree representing a berry bush where each node represents the number of berries on a branch of the bush, write a function `harvest_berries()`, that finds the number of berries you can harvest by returning the sum of all nodes with value greater than `threshold`.

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

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

def harvest_berries(root, threshold):
  pass
```

Example Usage:

```
"""
       4
     /   \
   10     6
  /  \     \
 5    8    20
"""
bush = TreeNode(4, TreeNode(10, TreeNode(5), TreeNode(8)), TreeNode(6, None, TreeNode(20)))

print(harvest_berries(bush, 6))
print(harvest_berries(bush, 30))
```

Example Output:

```
38
Example 1 Explanation:
- Nodes greater than 6: 8, 10, 20
- 8 + 10 + 20 = 38

0
Example 2 Explanation: No nodes greater than 30
```

Problem 8: Flower Fields

You're looking for the perfect bloom to add to your bouquet of flowers. Given the `root` of a binary tree representing flower options, and a target flower `flower`, return `True` if the bloom you are looking for each exists in the tree and `False` otherwise.

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

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

def find_flower(root, flower):
  pass
```

Example Usage:

```
"""
         Rose
        /    \
       /      \
     Lily     Daisy
    /    \        \
Orchid  Lilac    Dahlia
"""

flower_field = TreeNode("Rose",
                        TreeNode("Lily", TreeNode("Orchid"), TreeNode("Lilac")),
                                TreeNode("Daisy", None, TreeNode("Dahlia")))

print(find_flower(flower_field, "Lilac"))
print(find_flower(flower_field, "Hibiscus"))
```

Example Output:

```
True
False
```

Close Section

▼ Standard Problem Set Version 2

Problem 1: Building an Underwater Kingdom

Given the following `TreeNode` class, create the binary tree depicted below. The text representing each node should should be used as the `value`.

The `root`, or topmost node in the tree `TreeNode("Poseidon")` has been provided for you.

```
            Poseidon
          /         \
      Atlantis      Oceania
      /     \       /     \
  Coral     Pearl  Kelp    Reef
```

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

root = TreeNode("Poseidon")
# Add your code here
```

Example Usage:

```
# Using print_tree() included at the top of this page
print_tree(root)
```

Example Output:

```
['Poseidon', 'Atlantis', 'Oceania', 'Pearl', 'Kelp', 'Reef']
```

▼ ✨ AI Hint: Binary Trees

Key Skill: Use AI to explain code concepts

This problem requires you to understand binary trees. For a refresher on this topic, check out the Binary Trees section of the Unit 8 Cheatsheet.

If you need more help, try asking an AI tool like ChatGPT or GitHub Copilot to explain the concept of binary trees using a real-world analogy, and any following questions you have.

Once you grasp the idea, you can ask it to show you examples of binary trees in Python.

Problem 2: Are Twins?

Given the `root` of a binary tree that has at most three nodes: the `root`, its left child, and its right child.

Return `True` if the `root`'s children are twins (have equal value) and `False` otherwise. If the `root` has no children, return `False`.

Evaluate the time complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time complexity.

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

def mertwins(root):
    pass
```

Example Usage:

```
"""
      Mermother
       /    \
    Coral   Coral
"""
root1 = TreeNode("Mermother", TreeNode("Coral"), TreeNode("Coral"))

"""
      Merpapa
       /    \
   Calypso  Coral
"""
root2 = TreeNode("Merpapa", TreeNode("Calypso"), TreeNode("Coral"))

"""
      Merenby
           \
         Calypso
"""
root3 = TreeNode("Merenby", None, TreeNode("Calypso"))

print(mertwins(root1))
print(mertwins(root2))
print(mertwins(root3))
```

Example Output:

```
True
False
False
```

Problem 3: Poseidon's Decision

Poseidon has received advice on an important matter from his council of advisors. Help him evaluate the advice from his council to make a final decision. You are given the advice as the `root` of a binary tree representing a boolean expression that has at most three nodes. The `root` may have exactly 0 or 2 children.

- **Leaf nodes** have a boolean value of either `True` or `False`.
- **Non-leaf nodes** have a string value of either `AND` or `OR`.

The **evaluation** of a node is as follows:

- If the node is a leaf node, the evaluation is the **value** of the node, i.e. `True` or `False`.
- Otherwise evaluate the node's two children and apply the boolean operation of its value with the children's evaluations.

Return the boolean result of evaluating the `root` node.

Evaluate the time complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time complexity.

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

def get_decision(root):
  pass
```

Example Usage:

```
"""
        OR
      /    \
    True  False
"""
expression1 = TreeNode("OR", TreeNode(True), TreeNode(False))

"""
       False
"""
expression2 = TreeNode(False)

print(get_decision(expression1))
print(get_decision(expression2))
```

Example Output:

```
True
False
```

Problem 4: Escaping the Sea Caves

You are given the `root` of a binary tree representing possible route through a system of sea caves. You recall that so long as you take the leftmost branch at every fork in the route, you'll find your way back home. Write a function `leftmost_path()` that returns an array with the value of each node in the leftmost path.

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

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

def leftmost_path(root):
    pass
```

Example Usage:

```
"""
        CaveA
       /      \
    CaveB    CaveC
    /   \        \
CaveD CaveE     CaveF
"""
system_a = TreeNode("CaveA",
                  TreeNode("CaveB", TreeNode("CaveD"), TreeNode("CaveE")),
                          TreeNode("CaveC", None, TreeNode("CaveF")))

"""
  CaveA
      \
      CaveB
        \
        CaveC
"""
system_b = TreeNode("CaveA", None, TreeNode("CaveB", None, TreeNode("CaveC")))

print(leftmost_path(system_a))
print(leftmost_path(system_b))
```

Example Output:

```
['CaveA', 'CaveB', 'CaveD']
['CaveA']
```

▼ ✨ AI Hint: Balanced Trees

Tree problems will often specify whether or not you can assume a tree is balanced. This can affect the time complexity of your algorithm.

For a quick refresher, check out the Balanced Tree section of the Unit 8 Cheatsheet. If you need more help, try using an AI tool like ChatGPT or GitHub Copilot to show you examples of balanced trees and how they work. For example, you could ask:

"You're an expert computer science tutor. Can you help me understand the concept of a balanced binary tree, using multiple examples and an analogy to real-world objects?"

Problem 5: Escaping the Sea Caves II

If you implemented `leftmost_path()` iteratively in the previous problem, implement it recursively. If you implemented it recursively, implement it iteratively.

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

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

def leftmost_path(root):
    pass
```

Example Usage:

```
"""
        CaveA
       /      \
    CaveB    CaveC
    /   \        \
CaveD CaveE     CaveF
"""
system_a = TreeNode("CaveA",
                  TreeNode("CaveB", TreeNode("CaveD"), TreeNode("CaveE")),
                          TreeNode("CaveC", None, TreeNode("CaveF")))

"""
  CaveA
      \
      CaveB
        \
        CaveC
"""
system_b = TreeNode("CaveA", None, TreeNode("CaveB", None, TreeNode("CaveC")))

print(leftmost_path(system_a))
print(leftmost_path(system_b))
```

Example Output:

```
['CaveA', 'CaveB', 'CaveD']
['CaveA']
```

Problem 6: Documenting Reefs

You are exploring a vast coral reef system. The reef is represented as a binary tree, where each node corresponds to a specific coral formation. You want to document the reef as you encounter it, starting from the `root` or main entrance of the reef.

Write a function `explore_reef()` that performs a preorder traversal of the reef and returns a list of the names of the coral formations in the order you visited them. In a preorder exploration, you explore the current node first, then the left subtree, and finally the right subtree.

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

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

def explore_reef(root):
    pass
```

Example Usage:

```
"""
         CoralA
        /     \
     CoralB  CoralC
     /   \
 CoralD CoralE
"""

reef = TreeNode("CoralA",
                TreeNode("CoralB", TreeNode("CoralD"), TreeNode("CoralE")),
                          TreeNode("CoralC"))

print(explore_reef(reef))
```

Example Output:

```
['CoralA', 'CoralB', 'CoralD', 'CoralE', 'CoralC']
```

▼ ✨ AI Hint: Traversing Trees

Key Skill: Use AI to explain code concepts

This problem requires you to traverse a binary tree. For a refresher on this topic, check out the Tree Traversal section of the Unit 8 Cheatsheet.

Still have questions? Try asking an AI tool like ChatGPT or GitHub Copilot to explain the different types of binary tree traversal. You can use the following prompt as a starting point:

"You're an expert computer science tutor. Please explain the different types of binary tree traversal, and show me how they would each work on an example tree."

Hint: Be sure to learn about "preorder", "postorder", and "inorder" traversals!

Problem 7: Coral Count

Due to climate change, you have noticed that coral has been dying in the reef near Atlantis. You want to ensure there is still a healthy level of coral in the reef. Given the `root` of a binary tree where each node represents a coral in the reef, write a function `count_coral()` that returns the number of corals in the reef.

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

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

def count_coral(root):
    pass
```

Example Usage:

```
"""
          Staghorn
         /        \
        /          \
    Sea Fan      Sea Whip
    /     \       /
 Bubble  Table  Star
  /
Fire
"""
reef1 = TreeNode("Staghorn",
                TreeNode("Sea Fan", TreeNode("Bubble", TreeNode("Fire")), TreeNode("Table"))
                        TreeNode("Sea Whip", TreeNode("Star")))

"""
     Fire
    /    \
   /      \
Black    Star
        /
     Lettuce
           \
        Sea Whip
"""
reef2 = TreeNode("Fire",
                TreeNode("Black"),
                        TreeNode("Star",
                                 TreeNode("Lettuce", None, TreeNode("Sea Whip"))))

print(count_coral(reef1))
print(count_coral(reef2))
```

Example Output:

```
7
5
```

Problem 8: Ocean Layers

Given the `root` of a binary tree that represents different sections of the ocean, write a function `count_ocean_layers()` that returns the depth of the ocean. The **depth** or **height** of the tree can be defined as the number of nodes on the longest path from the root node to a leaf node.

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

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

def ocean_depth(root):
    pass
```

Example Usage:

```
"""
                Sunlight
               /        \
              /          \
          Twilight      Squid
         /       \           \
      Abyss  Anglerfish    Giant Squid
      /
  Trenches
"""
ocean = TreeNode("Sunlight",
                TreeNode("Twilight",
                        TreeNode("Abyss",
                                TreeNode("Trenches")), TreeNode("Anglerfish")),
                                        TreeNode("Squid", TreeNode("Giant Squid")))

"""
    Spray Zone
    /         \
   /           \
Beach       High Tide
            /
      Middle Tide
               \
            Low Tide
"""
tidal_zones = TreeNode("Spray Zone",
                       TreeNode("Beach"),
                               TreeNode("High Tide",
                                       TreeNode("Middle Tide", None, TreeNode("Low Tide"))))

print(ocean_depth(ocean))
print(ocean_depth(tidal_zones))
```

Example Output:

```
4
4
```

▾ Advanced Problem Set Version 1

Problem 1: Ivy Cutting

You have a trailing ivy plant represented by a binary tree. You want to take a cutting to start a new plant using the rightmost vine in the plant. Given the `root` of the plant, return a list with the value of each node in the path from the `root` node to the rightmost leaf 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 right_vine(root):
  pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""
ivy1 = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

"""
      Root
      /
    Node1
    /
  Leaf1
"""
ivy2 = TreeNode("Root", TreeNode("Node1", TreeNode("Leaf1")))

print(right_vine(ivy1))
print(right_vine(ivy2))
```

Example Output:

```
['Root', 'Node2', 'Leaf3']
['Root']
```

▼ ✨ AI Hint: Binary Trees

Key Skill: Use AI to explain code concepts

This problem requires you to understand binary trees. For a refresher on this topic, check out the Binary Trees section of the Unit 8 Cheatsheet.

If you need more help, try asking an AI tool like ChatGPT or GitHub Copilot to explain the concept of binary trees using a real-world analogy, and any following questions you have.

Once you grasp the idea, you can ask it to show you examples of binary trees in Python.

Problem 2: Ivy Cutting II

If you implemented `right_vine()` iteratively in the previous problem, implement it recursively. If you implemented it recursively, implement it iteratively.

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 right_vine(root):
  pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""
ivy1 = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1")),
                TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

"""
      Root
      /
    Node1
    /
  Leaf1
"""
ivy2 = TreeNode("Root", TreeNode("Node1", TreeNode("Leaf1")))

print(right_vine(ivy1))
print(right_vine(ivy2))
```

Example Output:

```
['Root', 'Node2', 'Leaf3']
['Root']
```

Problem 3: Pruning Plans

You have a large overgrown Magnolia tree that's in desperate need of some pruning. Before you can prune the tree, you need to do a full survey of the tree to evaluate which sections need to be pruned.

Given the `root` of a binary tree representing the magnolia, return a list of the values of each node using a postorder traversal. In a postorder traversal, you explore the left subtree first, then the right subtree, and finally the root. Postorder traversals are often used when deleting nodes from a 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 survey_tree(root):
    pass
```

Example Usage:

```
"""
        Root
      /      \
    Node1    Node2
  /         /    \
Leaf1    Leaf2  Leaf3
"""

magnolia = TreeNode("Root",
                TreeNode("Node1", TreeNode("Leaf1"))
                        TreeNode("Node2", TreeNode("Leaf2"), TreeNode("Leaf3")))

print(survey_tree(magnolia))
```

Example Output:

```
['Leaf1', 'Node1', 'Leaf2', 'Leaf3', 'Node2', 'Root']
```

▼ ✨ AI Hint: Traversing Trees

Key Skill: Use AI to explain code concepts

This problem requires you to traverse a binary tree. For a refresher on this topic, check out the Tree Traversal section of the Unit 8 Cheatsheet.

Still have questions? Try asking an AI tool like ChatGPT or GitHub Copilot to explain the different types of binary tree traversal. You can use the following prompt as a starting point:

"You're an expert computer science tutor. Please explain the different types of binary tree traversal, and show me how they would each work on an example tree."

Hint: Be sure to learn about "preorder", "postorder", and "inorder" traversals!

Problem 4: Sum Inventory

A local flower shop stores its inventory in a binary tree, where each node represents their current stock of a flower variety. Given the root of a binary tree `inventory`, return the sum of all the flower stock in the store.

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 sum_inventory(inventory):
    pass
```

Example Usage:

```
"""
     40
    /  \
   5   10
  /   /  \
20   1   30
"""

inventory = TreeNode(40,
                     TreeNode(5, TreeNode(20)),
                             TreeNode(10, TreeNode(1), TreeNode(30)))

print(sum_inventory(inventory))
```

Example Output:

```
106
```

Problem 5: Calculating Yield II

You have a fruit tree represented as a binary tree. Given the `root` of the tree, evaluate the amount of fruit your tree will yield this year. The tree has the following form:

- **Leaf nodes** have an integer value.
- **Non-leaf nodes** have a string value of either `"+"`, `"-"`, `"*"`, or `"-"`.

The **yield** of a the tree is calculated as follows:

- If the node is a leaf node, the yield is the **value** of the node.
- Otherwise evaluate the node's two children and apply the mathematical operation of its value with the children's evaluations.

Return the result of evaluating the `root` 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 calculate_yield(root):
  pass
```

Example Usage:

```
"""
      +
     / \
    /   \
   -     *
  / \   / \
 4   2 10  2
"""

root = TreeNode("+")
root.left = TreeNode("-")
root.right = TreeNode("*")
root.left.left = TreeNode(4)
root.left.right = TreeNode(2)
root.right.left = TreeNode(10)
root.right.right = TreeNode(2)

print(get_decision(apple_tree))
```

Example Output:

```
22
Explanation:
- 4 - 2 = 2
- 10 * 2 = 20
- 2 + 20 = 22
```

Problem 6: Plant Classifications

Given the `root` of a binary tree used to classify plants where each level of the tree represents a higher degree of speficity, return an array with the most specific plant classification categories (aka the leaf node values). Leaf nodes are nodes with no children.

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 get_most_specific(taxonomy):
    pass
```

Example Usage:

```
"""
           Plantae
          /       \
         /         \
        /           \
Non-flowering     Flowering
   /      \       /        \
Mosses   Ferns Gymnosperms Angiosperms
                            /     \
                        Monocots  Dicots
"""
plant_taxonomy = TreeNode("Plantae",
                          TreeNode("Non-flowering", TreeNode("Mosses"), TreeNode("Ferns")),
                                  TreeNode("Flowering", TreeNode("Gymnosperms"),
                                          TreeNode("Angiosperms", TreeNode("Monocots"), TreeN

print(get_most_specific(plant_taxonomy))
```

Example Output:

```
['Mosses', 'Ferns', 'Gymnosperms', 'Monocots', 'Dicots']
```

Problem 7: Count Old Growth Trees

Given the `root` of a binary tree where each node represents the age of a tree in a forest, write a function `count_old_growth()` that returns the number of old growth trees in the forest. A tree is considered old growth if it has age greater than `threshold`.

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 count_old_growth(root, threshold):
    pass
```

Example Usage:

```
"""
     100
     /  \
    /    \
  1200  1500
  /     /  \
20    700  2600
"""

forest = TreeNode(100,
                  TreeNode(1200, TreeNode(20))
                          TreeNode(1500, TreeNode(700), TreeNode(2600)))

print(count_old_growth(forest, 1000))
```

Example Output:

```
3
```

Problem 8: Twinning Trees

Given the roots of two trees `root1` and `root2`, return `True` if the trees have identical structures and values 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 is_identical(root1, root2):
    pass
```

Example Usage:

```
"""
      1               1
     / \             / \
    2   3           2   3
"""
root1 = TreeNode(1, TreeNode(2), TreeNode(3))
root2 = TreeNode(1, TreeNode(2), TreeNode(3))

"""
      1               1
     /                 \
    2                   2
"""

root3 = TreeNode(1, TreeNode(2))
root4 = TreeNode(1, None, TreeNode(2))

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

Example Output:

```
True
False
```

Close Section

▼ Advanced Problem Set Version 2

Problem 1: Escaping the Sea Caves

You are given the `root` of a binary tree representing possible route through a system of sea caves. You recall that so long as you take the leftmost branch at every fork in the route, you'll find your way back home. Write a function `leftmost_path()` that returns an array with the value of each node in the leftmost path.

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 leftmost_path(root):
    pass
```

Example Usage:

```
"""
        CaveA
       /      \
    CaveB    CaveC
    /   \        \
CaveD CaveE     CaveF
"""
system_a = TreeNode("CaveA",
                  TreeNode("CaveB", TreeNode("CaveD"), TreeNode("CaveE")),
                          TreeNode("CaveC", None, TreeNode("CaveF")))

"""
  CaveA
      \
      CaveB
        \
        CaveC
"""
system_b = TreeNode("CaveA", None, TreeNode("CaveB", None, TreeNode("CaveC")))

print(leftmost_path(system_a))
print(leftmost_path(system_b))
```

Example Output:

```
['CaveA', 'CaveB', 'CaveD']
['CaveA']
```

▼ ✨ AI Hint: Binary Trees

Key Skill: Use AI to explain code concepts

This problem requires you to understand binary trees. For a refresher on this topic, check out the Binary Trees section of the Unit 8 Cheatsheet.

If you need more help, try asking an AI tool like ChatGPT or GitHub Copilot to explain the concept of binary trees using a real-world analogy, and any following questions you have.

Once you grasp the idea, you can ask it to show you examples of binary trees in Python.

Problem 2: Escaping the Sea Caves II

If you implemented `leftmost_path()` iteratively in the previous problem, implement it recursively. If you implemented it recursively, implement it iteratively.

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 leftmost_path(root):
    pass
```

Example Usage:

```
"""
        CaveA
       /      \
    CaveB    CaveC
    /   \        \
CaveD CaveE     CaveF
"""
system_a = TreeNode("CaveA",
                  TreeNode("CaveB", TreeNode("CaveD"), TreeNode("CaveE")),
                          TreeNode("CaveC", None, TreeNode("CaveF")))

"""
  CaveA
      \
      CaveB
        \
        CaveC
"""
system_b = TreeNode("CaveA", None, TreeNode("CaveB", None, TreeNode("CaveC")))

print(leftmost_path(system_a))
print(leftmost_path(system_b))
```

Example Output:

```
['CaveA', 'CaveB', 'CaveD']
['CaveA']
```

Problem 3: Count the Food Chain

Given the `root` of a binary tree representing a marine food chain, return the number of species (nodes) in the chain.

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 count_species(node):
    pass
```

Example Usage:

```
"""
         Shark
       /       \
      /         \
   Grouper     Snapper
   /     \           \
Conch   Tang       Zooplankton
"""

food_chain = TreeNode("Shark",
                    TreeNode("Grouper", TreeNode("Conch"), TreeNode("Tang")),
                            TreeNode("Snapper", None, TreeNode("Zooplankton")))

print(count_species(food_chain))
```

Example Output:

```
6
```

▼ ✨ AI Hint: Traversing Trees

Key Skill: Use AI to explain code concepts

This problem requires you to traverse a binary tree. For a refresher on this topic, check out the Tree Traversal section of the Unit 8 Cheatsheet.

Still have questions? Try asking an AI tool like ChatGPT or GitHub Copilot to explain the different types of binary tree traversal. You can use the following prompt as a starting point:

"You're an expert computer science tutor. Please explain the different types of binary tree traversal, and show me how they would each work on an example tree."

Hint: Be sure to learn about "preorder", "postorder", and "inorder" traversals!

Problem 4: Documenting Reefs

You are exploring a vast coral reef system. The reef is represented as a binary tree, where each node corresponds to a specific coral formation. You want to document the reef as you encounter it, starting from the `root` or main entrance of the reef.

Write a function `explore_reef()` that performs a preorder traversal of the reef and returns a list of the names of the coral formations in the order you visited them. In a preorder exploration, you explore the current node first, then the left subtree, and finally the 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 explore_reef(root):
    pass
```

Example Usage:

```
"""
         CoralA
        /     \
     CoralB  CoralC
     /   \
 CoralD CoralE
"""

reef = TreeNode("CoralA",
                TreeNode("CoralB", TreeNode("CoralD"), TreeNode("CoralE")),
                          TreeNode("CoralC"))

print(explore_reef(reef))
```

Example Output:

```
['CoralA', 'CoralB', 'CoralD', 'CoralE', 'CoralC']
```

Problem 5: Poseidon's Decision II

Poseidon has received advice on an important matter from his council of advisors. Help him evaluate the advice from his council to make a final decision. You are given the advice as the `root` of a binary tree representing a boolean expression.

- **Leaf nodes** have a boolean value of either `True` or `False`.
- **Non-leaf nodes** have two children and a string value of either `AND` or `OR`.

The **evaluation** of a node is as follows:

- If the node is a leaf node, the evaluation is the **value** of the node, i.e. `True` or `False`.
- Otherwise evaluate the node's two children and apply the boolean operation of its value with the children's evaluations.

Return the boolean result of evaluating the `root` 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 get_decision(node):
    pass
```

Example Usage:

```
"""
        AND
     /      \
   OR       AND
  /  \       /  \
True False True False
"""

root = TreeNode("AND")
root.left = TreeNode("OR")
root.right = TreeNode("AND")
root.left.left = TreeNode(True)
root.left.right = TreeNode(False)
root.right.left = TreeNode(True)
root.right.right = TreeNode(False)
print(get_decision(root))
```

Example Output:

```
False
Explanation:
- Left Subtree Evaluation: True OR False evaluates to True
- Right Subtree Evaluation: True AND False evaluates to False
- Root and children Evaluation: True AND False evaluates to False
```

Problem 6: Uniform Coral

Triton is looking for the perfect piece of coral to gift his mother, Amphitrite, for her birthday. Given the `root` of a binary tree representing a coral structure, write a function `is_uniform()` that evaluates the quality of the coral. The function should return `True` if each node in the coral tree has the same value 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 is_uniform(root):
    pass
```

Example Usage:

```
"""
         1
        / \
       1   1
      / \
     1   1
"""
coral = TreeNode(1, TreeNode(1, TreeNode(1), TreeNode(1)), TreeNode(1))


"""
   1
  / \
 2   1
"""
coral2 = TreeNode(1, TreeNode(2), TreeNode(1))

print(is_uniform(coral))
print(is_uniform(coral2))
```

Example Output:

```
True
False
```

Problem 7: Biggest Pearl

You are searching through a bed of oysters and searching for the oyster with the largest pearl. Given the `root` of a binary tree where each node represents the size of a pearl, return the size of the largest pearl.

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_largest_pearl(root):
    pass
```

Example Usage:

```
"""
         7
        / \
       6   0
      / \
     5   1
"""
oysters = TreeNode(7, TreeNode(6, TreeNode(5), TreeNode(1)), TreeNode(0))


"""
   1
  / \
 0   1
"""
oysters2 = TreeNode(1, TreeNode(0), TreeNode(1))

print(find_largest_pearl(oysters))
print(find_largest_pearl(oysters2))
```

Example Output:

```
7
1
```

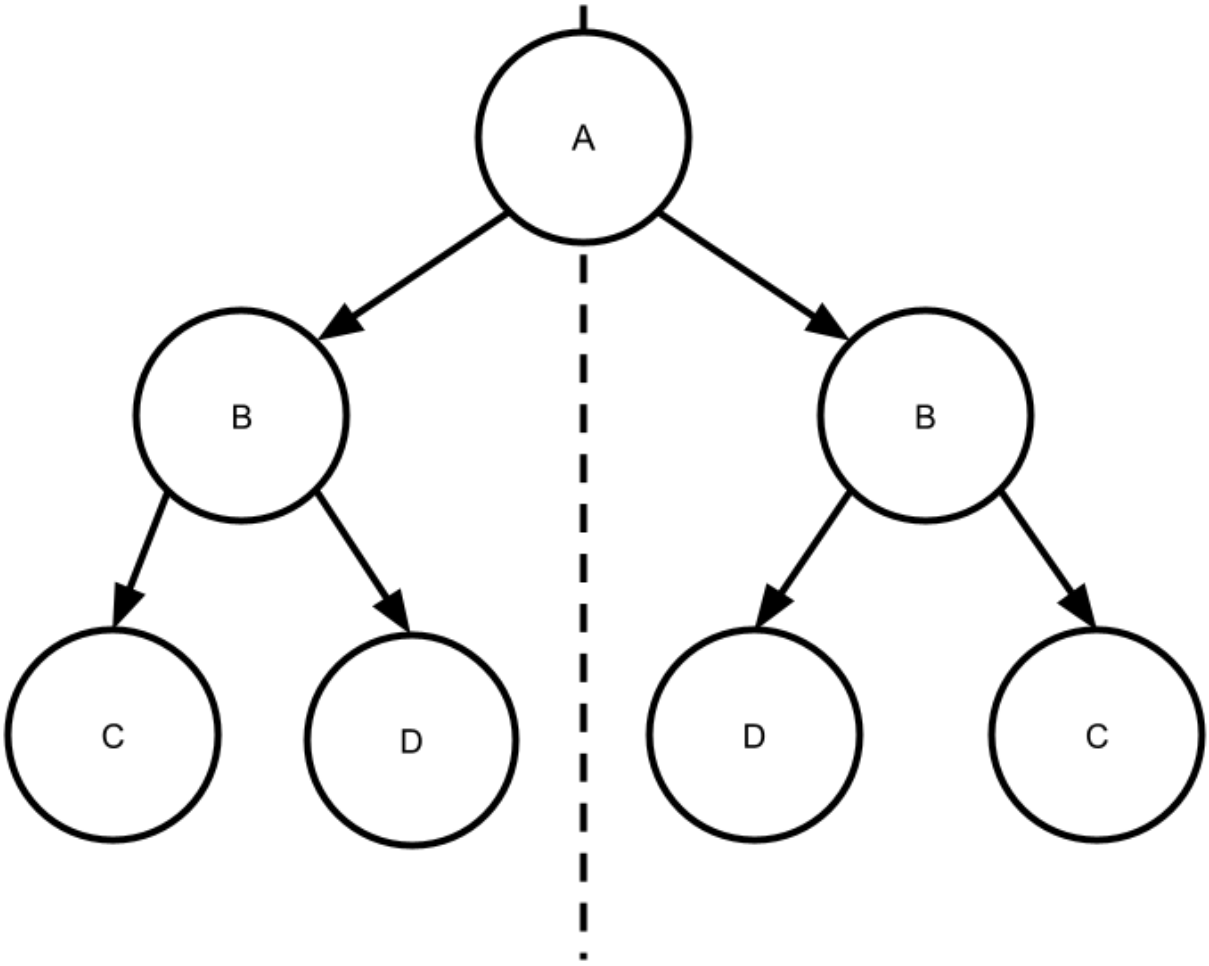
Problem 8: Coral Reef Symmetry

Given the `root` of a binary tree representing a coral, return `True` if the coral is symmetric around its center and `False` otherwise. A coral is symmetric if the left and right subtrees are mirror images of each other.

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.

```
"""
# Example 1

# Input: root = CoralKing
# Expected Output: True

# Example 2

    CoralQueen
     /      \
 CoralX    CoralX
  /  \      /  \
CoralY CoralZ CoralY CoralZ

# Input: root = CoralQueen
# Expected Output: False
"""

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

def is_symmetric(root):
    pass
```

Example Usage:




```
"""
        A
      /   \
     B     B
    / \   / \
   C  D   D  C
"""
coral1 = TreeNode('A',
                  TreeNode('B', TreeNode('C'), TreeNode('D')),
                          TreeNode('B', TreeNode('D'), TreeNode('C')))


"""
        A
      /   \
     B     B
    / \   / \
   C  D   C  D
"""
coral2 = TreeNode('A',
                  TreeNode('B', TreeNode('C'), TreeNode('D')),
                          TreeNode('B', TreeNode('C'), TreeNode('D')))

print(is_symmetric(coral1))
print(is_symmetric(coral2))
```

Example Output:

```
True
False
```

Close Section