Guerrilla Section 3: Data Abstraction, Trees, and Growth

Instructions

Form a group of 3-4. Start on Question 0. Check off with a lab assistant when everyone in your group understands how to solve Question 0. Repeat for Question 1, 2, etc. **You're not allowed to move on from a question until you check off with a tutor.** You are allowed to use any and all resources at your disposal, including the interpreter, lecture notes and slides, discussion notes, and labs. You may consult the lab assistants, **but only after you have asked everyone else in your group. The purpose of this section is to have all the students working together to learn the material.**

Mutability

Question 0

a. Name two data types that are mutable. What does it mean to be mutable?

b. Name two data types that are not mutable.

Question 1

a. Will the following code error? Why?

```
>>> a = 1
>>> b = 2
>>> dt = {a: 1, b: 2}
```

b. Will the following code error? Why?

```
>>> a = [1]
>>> b = [2]
>>> dt = {a: 1, b: 2}
```

Question 2

a. Fill in the output and draw a box-and-pointer diagram for the following code. If an error occurs, write “Error”, but include all output displayed before the error.

```
>>> a = [1, [2, 3], 4]
>>> c = a[1]
>>> c
```

```
>>> a.append(c)
>>> a
```

```
>>> c[0] = 0
>>> c
```

```
>>> a
```

```
>>> a.extend(c)
>>> c[1] = 9
>>> a
```

---

b. Fill in the output and draw a box-and-pointer diagram for the following code. If an error occurs, write "Error", but include all output displayed before the error.

```
>>> lst = [5, 6, 7]
>>> risk = [5, 6, 7]
>>> lst, risk = risk, lst
>>> lst is risk
```

____

```
>>> mist = risk
>>> risk = risk[0:4]
>>> mist.insert(-1, 99)
>>> risk[-1]
```

____

```
# Hint: Try drawing the result of [y + 1 for y in mist] first.
>>> risk = [x for  x in [y + 1 for y in mist] if x % 10 != 0]
>>> risk
```

____

```
>>> er = [1, 2]
>>> er.extend(risk.pop())
```

____

STOP!

Don't proceed until everyone in your group has finished and understands all exercises in this section, and you have gotten checked off!

<u>Data Abstraction</u>

Question 1

a. Why are Abstract Data Types useful?

b. What are the two types of functions necessary to make an Abstract Data Type? Describe what they do.

c. What is a Data Abstraction Violation?

d. Why is it a terrible sin to commit a Data Abstraction Violation?

Question 2

In lecture, we discussed the rational data type, which represents fractions with the following methods:

• `rational(n, d)` - constructs a rational number with numerator n, denominator d •
`numer(x)` - returns the numerator of rational number x
• `denom(x)` - returns the denominator of rational number x

We also presented the following methods that perform operations with rational numbers:

- `add_rationals(x, y)`
- `mul_rationals(x, y)`
- `rationals_are_equal(x, y)`

You'll soon see that we can do a lot with just these simple methods in the exercises below.

a. Write a function that returns the given rational number x raised to positive power e.

```
from math import pow

def rational_pow(x, e):
    """
    >>> r = rational_pow(rational(2, 3), 2)
    >>> numer(r)
    4
    >>> denom(r)
    9

    >>> r2 = rational_pow(rational(9, 72), 0)
    >>> numer(r2)
    1
    >>> denom(r2)
    1
    """
```

b. Implement the following rational number methods.

```
def inverse_rational(x):
    """ Returns the inverse of the given non-zero rational number
    >>> r = rational(2, 3)
    >>> r_inv = inverse_rational(r)
    >>> numer(r_inv)
    3
    >>> denom(r_inv)
    2

    >>> r2 = rational_pow(rational(3, 4), 2)
    >>> r2_inv = inverse_rational(r2)
    >>> numer(r2_inv)
    16
    >>> denom(r2_inv)
    9
    """
```

```
def div_rationals(x, y): # Hint: Use functions defined in Question 2
    """ Returns x / y for given rational x and non-zero rational y
    >>> r1 = rational(2, 3)
    >>> r2 = rational(3, 2)
    >>> div_rationals(r1, r2)
    [4, 9]
    >>> div_rationals(r1, r1)
    [6, 6]
    """
```

c. The irrational number e ≈ 2.718 can be generated from an infinite series. Let's try calculating it using our rational number data type! The mathematical formula is as follows:

$$e = \frac{1}{0!} + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \dots$$

Write a function approx_e that returns a rational number approximation of e to iter amount of iterations. We've provided a factorial function.

```
def factorial(n):
    If n == 0:
        return 1
    else:
        return n * factorial(n - 1)



def approx_e(iter):
```

Question 3

Assume that `rational, numer,` and `denom`, run without error and work like the ADT defined in Question 2. Can you identify where the abstraction barrier is broken? Come up with a scenario where this code runs without error and a scenario where this code would stop working.

```
def rational(num, den): # Returns a rational number ADT
    #implementation not shown
def numer(x): # Returns the numerator of the given rational
    #implementation not shown
def denom(x): # Returns the denominator of the given rational
    #implementation not shown
def gcd(a, b): # Returns the GCD of two numbers
    #implementation not shown

def simplify(f1): #Simplifies a rational number
    g = gcd(f1[0], f1[1])
    return rational(numer(f1) // g, denom(f1) // g)


def multiply(f1, f2): # Multiples and simplifies two rational numbers
    r = rational(numer(f1) * numer(f2), denom(f1) * denom(f2))
    return simplify(r)

x = rational(1, 2)
y = rational(2, 3)
multiply(x, y)
```

STOP!

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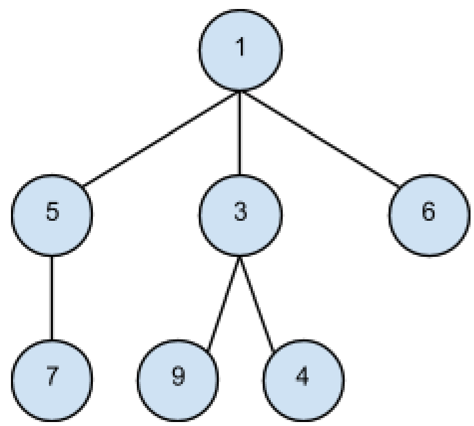
Trees

Question 0

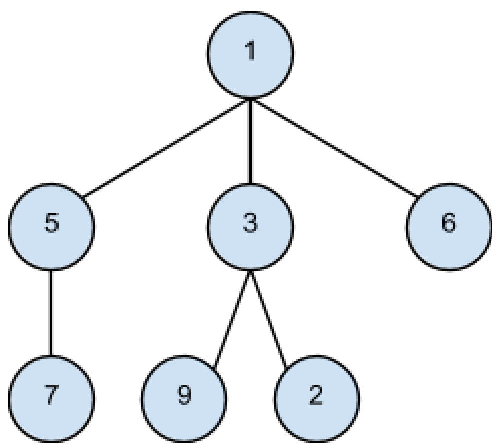
a. Fill in this implementation of a tree:

```
def tree(label, branches = []):
    for b in branches:
        assert is_tree(b), 'branches must be trees'
    return [label] + list(branches)



def is_tree(tree):
    if type(tree) != list or len(tree) < 1:
        return False
    for b in branches(tree):
        if not is_tree(b):
            return False
    return True



def label(tree):



def branches(tree):



def is_leaf(tree):
```

b. A *min-heap* is a tree with the special property that every node's value is less than or equal to the values of all of its children. For example, the following tree is a min-heap:



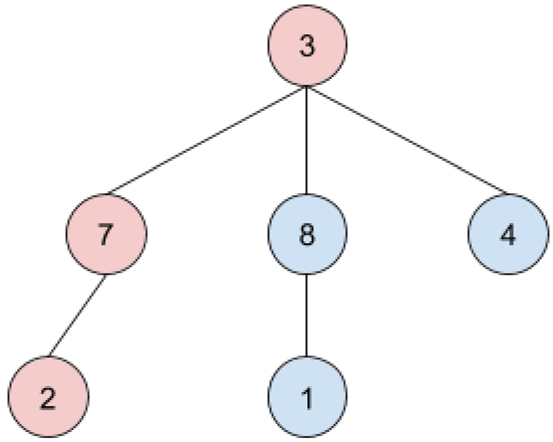
However, the following tree is *not* a min-heap because the node with value 3 has a value greater than one of its children:



Write a function `is_min_heap` that takes a tree and returns `True` if the tree is a min-heap and `False` otherwise.

```
def is_min_heap(t):
```

c. Write a function `largest_product_path` that finds the largest product path possible. A *product path* is defined as the product of all nodes between the root and a leaf. The function takes a tree as its parameter. Assume all nodes have a nonnegative value.



For example, calling `largest_product_path` on the above tree would return 42, since 3 * 7 * 2 is the largest product path.

```
def largest_product_path(tree):
    """
    >>> largest_product_path(None)
    0
    >>> largest_product_path(tree(3))
    3
    >>> t = tree(3, [tree(7, [tree(2)]), tree(8, [tree(1)]), tree(4)])
    >>> largest_product_path(t)
    42
    """
    if not _______________:
        return 0
    elif is_leaf(tree):

        return _______________________
    else:
        paths = [ ______________________________________________________________ ]

        return __________________________________
```

STOP!

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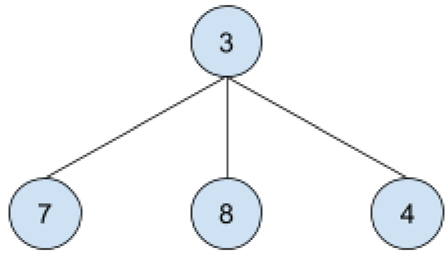
Challenge Question (Optional)
Come back after finishing everything!

The *level-order traversal* of a tree is defined as visiting the nodes in each level of a tree before moving onto the nodes in the next level. For example, the level order of the following tree is,



Level-order: 3 7 8 4

a. Write a function print_level_sorted that takes in a tree as the parameter and returns a list of the values of the nodes in level order.

```
def level_order(tree):
    """
    >>> t = tree(3, [tree(7, [tree(2, [tree(8), tree(1)]), tree(5)])])
    >>> level_order(t)
    [3 7 5 2 8 1]
    >>> level_order(tree(3))
    [3]
    >>> level_order(None)
    []
    """
    if not _______________:
        return []
    current_level, next_level = [label(tree)], [tree]

    while ________________:
        find_next = []

        for ______________ in ________________:

            ______________.extend(_____________________________)
        next_level = find_next

        current_level.extend(____________________________________________)
    return current_level
```

Growth

Question 0

What are the runtimes of the following?

```
def one(n):
    if 1 == 1:
        return None
    else:
        return n
```

a. θ(1)   b) θ(log n)   c) θ(n)   d) $θ(n^2)$ e) $θ(2^n)$

```
def two(n):
    for i in range(n):
        print(n)
```

b. θ(1)   b) θ(log n)   c) θ(n)   d) $θ(n^2)$ e) $θ(2^n)$

```
def three(n):
    while n > 0:
       n = n // 2
```

c. θ(1)   b) θ(log n)   c) θ(n)   d) $θ(n^2)$ e) $θ(2^n)$

```
def four(n):
    for i in range(n):
        for j in range(i):
            print(str(i), str(j))
```

d. θ(1)   b) θ(log n)   c) θ(n)   d) $θ(n^2)$ e) $θ(2^n)$

STOP!

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