Final Exam Review

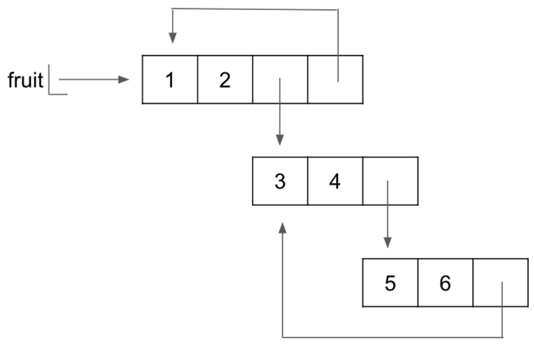
Computer Science Mentors 61A

December 9 – December 13, 2024

1 Environment Diagrams

1. Fill in each blank in the code example below so that its environment diagram is the following. You do not need to use all the blanks.

```
fruit = [1, 2, [3, 4]]
fruit.____________________
fruit[3][2].______________
fruit[2][2].______________
fruit[3][3][2][2][2][1] = ___
```



2 Iterators

2. Define a **non-decreasing path** as a path from the root where each node's label is greater than or equal to the previous node along the path. A **subpath** is a path between nodes X and Y, where Y must be a descendent of X (ex: Y is a branch of a branch of X).

(a) Write a generator function `root_to_leaf` that takes in a tree `t` and yields all non-decreasing paths from the root to a leaf node, in any order. Assume that `t` has at least one node.

```
def root_to_leaf(t):
    """
    >>> t1 = Tree(3, [Tree(5), Tree(4)])
    >>> list(root_to_leaf(t1))
    [[3, 5], [3, 4]]
    >>> t2 = Tree(5, [Tree(2, [Tree(7), Tree(8)]), Tree(5, [Tree(6)])])
    [[5, 5, 6]]
    """

    if ____________________:

        _________________________

    for _________________________:

        if __________________________:

            for __________________________:

                ______________________________
```

(b) Write a generator function `subpaths` that takes in a tree `t` and yields all non-decreasing subpaths that end with a leaf node, in any order. You may use the `root_to_leaf` function above, and assume again that `t` has at least one node.

```
def subpaths(t):

    yield from _______________________

    for b in t.branches:

        ______________________________
```

3 Data Abstraction

3. In the following problem, we will represent a bookshelf object using dictionaries.

   In the first section, we will set up the format. Here, we will directly work with the internals of the Bookshelf, so don't worry about abstraction barriers for now. Fill in the following functions based on their descriptions (the constructor is given to you):

```
def Bookshelf(capacity):
    """ Creates an empty bookshelf with a certain max capacity. """
    return {'size': capacity, 'books': {}}

def add_book(bookshelf, author, title):
    """
    Adds a book to the bookshelf. If the bookshelf is full,
    print "Bookshelf is full!" and do not add the book.
    >>> books = Bookshelf(2)
    >>> add_book(books, 'Jane Austen', 'Pride and Prejudice')
    >>> add_book(books, 'Daniel Kleppner', 'An Introduction to Mechanics
       5th Edition')
    >>> add_book(books, 'Kurt Vonnegut', 'Galapagos')
    Bookshelf is full!
    """
    if ___________________________________:
        print('Bookshelf is full!')
    else:
        if author in bookshelf['books']:
            ________________________________________
        else:
            ________________________________________


def get_all_authors(bookshelf):
    """
    Returns a list of all authors who have at least one book in the
       bookshelf.
    >>> books = Bookshelf(10)
    >>> add_book(books, 'Jane Austen', 'Pride and Prejudice')
    >>> add_book(books, 'Sheldon Axler', 'Linear Algebra Done Right')
    >>> add_book(books, 'Kurt Vonnegut', 'Galapagos')
    >>> get_all_authors(books)
    ['Jane Austen', 'Sheldon Axler', 'Kurt Vonnegut']
    """
    return _______________________________________
```

Now, complete the function `most_popular_author` **without breaking the abstraction barrier**. In other words, you are not allowed to assume anything about the implementation of a Bookshelf object, or use the fact that it is a dictionary. You can only use the methods above and their stated return values.

```
def most_popular_author(bookshelf):
    """
    Returns the author with the greatest number of books on this bookshelf.
    You can assume that the bookshelf is not empty.
    >>> books = Bookshelf(100)
    >>> add_book(books, 'Orson Scott Card', 'Xenocide')
    >>> add_book(books, 'Orson Scott Card', 'Children of the Mind')
    >>> add_book(books, 'J.R.R. Tolkien', 'The Hobbit')
    >>> most_popular_author(bookshelf)
    'Orson Scott Card'
    """
    return max(________________________________________________,

        key=_______________________________________________________)
```

4 Efficiency

4. Find the $\Theta(\cdot)$ runtime bound for `hiya(n)`. Remember that Python strings are immutable: when we add two strings together, we need to make a copy.

```
def hiii(m):
    word = "h"
    for i in range(m):
        word += "i"
    return word

def hiya(n):
    i = 1
    while i < n:
        print(hiii(i))
        i *= 2
```

5 OOP

Let's use OOP design to help us create a supermarket chain (think Costco)! There are many different ways to implement such a system, so there is no concrete answer.

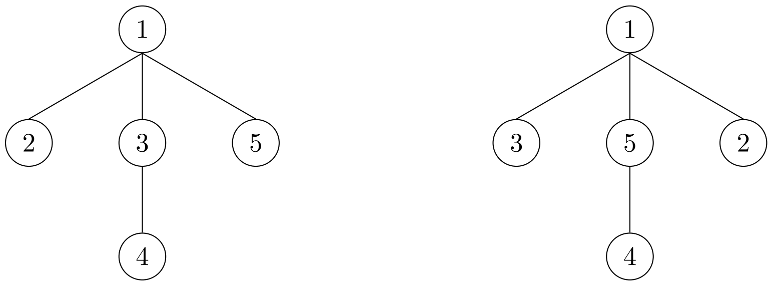
5. What classes should we consider having? How should each of these classes interact with each other?

6. For each class, what instance and class variables would it have?

7. For each class, what class methods would they have? How would they interact with each other?

8. Implement `rotate`, which takes in a tree and rotates the labels at each level of the tree by one to the left destructively. This rotation should be modular (That is, the leftmost label at a level will become the rightmost label after running rotate). You do NOT need to rotate across different branches.

   For example, given tree `t` on the left, `rotate(t)` should mutate `t` to give us the right.



```
def rotate(t):
  """
  >>> t1 = Tree(1, [Tree(2), Tree(3, [Tree(4)]), Tree(5)])
  >>> rotate(t1)
  >>> t1
  Tree(1, [Tree(3), Tree(5, [Tree(4)]), Tree(2)])
  >>> t2 = Tree(1, [Tree(2, [Tree(3), Tree(4)]),
                   Tree(5, [Tree(6)])])
  >>> rotate(t2)
  >>> t2
  Tree(1, [Tree(5, [Tree(4), Tree(3)]),
                   Tree(2, [Tree(6)])])
  """
  branch_labels = ______________________________

  n = len(t.branches)

  for _________________________________:

    ______________________________________

    ______________________________________

    ______________________________________
```

9. Star-Lord is cruising through space and can't afford to crash into any asteroids along the way. Let his path be represented as a (possibly nested) list of integers, where an asteroid is denoted with a 0, and stars and planets otherwise. Every time Star-lord sees (visits) an asteroid (0), he merges the next planet/star with the asteroid. In other words, construct a NEW list so that all asteroids (0s) are replaced with a list containing the planet followed by the asteroid (e.g. (planet 0)). You can assume that the last object in the path is not an asteroid (0).

```
;Doctests
scm> (collision (list 1 2 3 0 4))
(1 2 3 (4 0))
scm> (collision (list 4 3 (list 0 1) 2))
(4 3 ((1 0)) 2)
scm> (collision (list 1 -2 0 -3 4 0 -5 6))
(1 -2 (-3 0) 4 (-5 0) 6)
scm> (collision (list 1 0 0 2 3))
(1 (0 0) 2 3)

;Asteroids can merge with other asteroids too

(define (collision lst)

  (cond ((_____________________) lst)

    ((___________________________)

     __________________________________)

    ((___________________________)

     (cons ____________________________

       __________________________________))

    (else __________________________________)
  )
)
```