FINAL REVIEW Solutions

COMPUTER SCIENCE MENTORS

November 30, 2020 - December 3, 2020

1 Environment Diagrams

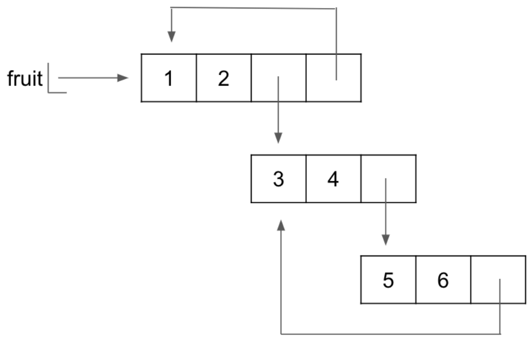
1. Draw the environment diagram that results from running the following code.

```
def f(f):
    def h(x, y):
        z = 4
        return lambda z:  (x + y) * z

    def g(y):
        nonlocal g, h
        g = lambda y: y[:4]
        h = lambda x, y: lambda f: f(x + y)
        return y[3] + y[5:8]

    return h(g("sarcasm!"), g("why?"))

f = f("61a")(2)
```

https://tinyurl.com/y56ezjz9

2. 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] = ____
```



```
fruit = [1, 2, [3, 4]]
fruit.append(fruit)
fruit[3][2].append([5, 6])
fruit[2][2].append(fruit[2])
fruit[3][3][2][2][2][1] = 4
```

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2 OOP

1. The `DLList` class is a spin off of the normal `Link` class we learned in class; each `DLList` link has a `prev` attribute that keeps track of the previous link and a **`next`** attribute that keeps track of the next link. Fill in the following methods for the `DLList` class.

   (a)
```
class DLList:
    """
    >>> lst = DLList(6, DLList(1))
    >>> lst.value
    6
    >>> lst.next.value
    1
    >>> lst.prev.value
    AttributeError: 'NoneType' object has no attribute 'value
       '
    """
    empty = None
    def __init__(self, value, next=empty, prev=empty):

      ________________________________

      ________________________________

      ________________________________

  def __init__(self, value, next=empty, prev=empty):
    self.value = value
    self.next = next
    self.prev = prev
```

   (b)
```
    def add_last(self, value):
      """
      >>> lst = DLList(6)
      >>> lst.add_last(1)
      >>> lst.value
      6
      >>> lst.next.value
      1
      >>> lst.next.prev.value
      6
      """
```

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```
    pointer = self
    while ________________________________:

      _____________________________________

    _______________ = DLList(____________________________)
```

```
def add_last(self, value):
  pointer = self
  while pointer.next != DLList.empty:
    pointer = pointer.next
  pointer.next = DLList(value, DLList.empty, pointer)
```

(c)

```
def add_first(self, value):
  """
  >>> lst = DLList('A')
  >>> lst.add_first(1)
  >>> lst.value
  1
  >>> lst.next.value
  'A'
  >>> lst.next.prev.value
  1
  >>> lst.add_first(6)
  >>> lst.value
  6
  >>> lst.next.next.prev.value
  1
  """
  old_first = DLList(____________________________)

  _______________ = _______________________________

  _______________ = _______________________________

  if ______________________________:

    _______________________________________________
```

```
def add_first(self, value):
  old_first = DLList(self.value, self.next, self)
  self.value = value
  self.next = old_first
```

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```
        if old_first.next != DLList.empty:
          old_first.next.prev = old_first
```

If you're looking for some more practice on OOP problems. Check out this worksheet! (link needed)

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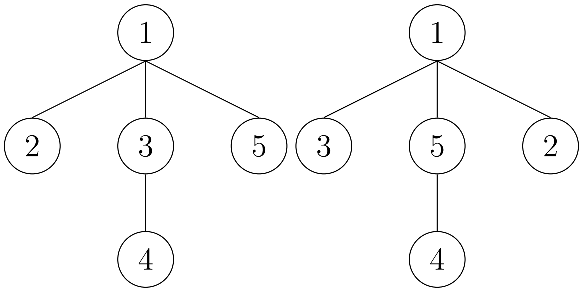
3 Trees

1. 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 ______________________________________:

        ____________________________________________

        ____________________________________________

        ____________________________________________
```

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```
def rotate(t):
  branch_labels = [b.label for b in t.branches]
  n = len(t.branches)
  for i in range(n):
    branch = t.branches[i]
    branch.label = branch_labels[(i + 1) % n]
    rotate(branch)
```

4 Generators

1. (a) Implement n_apply, which takes in 3 inputs f, n, x, and outputs the result of applying f, a function, n times to x. For example, for n = 3, output the result of f(f(f(x))).

```
def n_apply(f, n, x):
  """
  >>> n_apply(lambda x: x + 1, 3, 2)
  5
  """

  for __________________________:

    x = ________________________

  return _______________________
```

```
def n_apply(f, n, x):
  for i in range(n):
    x = f(x)
  return x
```

(b) Now implement list_gen, which takes in some list of integers lst and a function f. For the element at index i of lst, list_gen should apply f to the element i times and yield this value lst[i] times. You may use n_apply from the previous part.

```
def list_gen(lst, f):
  """
  >>> a = list_gen([1, 2, 3], lambda x: x + 1)
  >>> list(a)
  [1, 3, 3, 5, 5, 5]
  """
```

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```
    for ________________________________:

        yield from [__________________________________________________]

def list_gen(lst, f):
    for i in range(len(lst)):
        yield from [n_apply(f, i, lst[i]) for j in range(lst[i
            ])]
```

2. Complete the implementation of iter_link, which takes in a linked list and returns a generator which will iterate over the values of the linked list in order. Your function should support deep linked lists.

```
def iter_link(lnk):
  """
  Yield the values of a linked list in order; your function
     should support deep linked lists.
  >>> lst1 = Link(1, Link(2, Link(3, Link(4))))
  >>> list(iter_link(lst1))
  [1, 2, 3, 4]
  >>> lst2 = Link(1, Link(Link(2, Link(3)), Link(4, Link(5))))
  >>> print(lst2)
  <1 <2 3> 4 5>
  >>> iter_lst2 = iter_link(lst2)
  >>> next(iter_lst2)
  1
  >>> next(iter_lst2)
  2
  >>> next(iter_lst2)
  3
  >>> next(iter_lst2)
  4
  """
  if lnk is not Link.empty:

    if type(_____________________) is Link:

      _____________________________________
    else:

      _____________________________________

    _______________________________________
```

```
def iter_link(lnk):
  if lnk is not Link.empty:
    if type(lnk.first) is Link:
      yield from iter_link(lnk.first)
    else:
      yield lnk.first
    yield from iter_link(lnk.rest)
```

5 Scheme

1. Suppose Isabelle bought turnips from the Stalk Market and has stored them in random amounts among an ordered sequence of boxes. By the magic of time travel, Isabelle's friend Tom Nook can fast-forward one week into the future and determine exactly how many of Isabelle's turnips will rot over the week and have to be discarded.

   Assuming that boxes of turnips will rot in order, i.e. all of box 1's turnips will rot before any of box 2's turnips, help Isabelle determine which turnips will still be fresh by week's end. Specifically, fill in `decay`, which takes in a list of positive integers `boxes`, which represents how many turnips are in each box, and a positive integer `rotten` representing the number of turnips that will rot, and returns a list of non-negative integers that represents how many fresh turnips will remain in each box.

   ```
   ; doctests
   scm> (define a '(1 6 3 4))
   a
   scm> (decay a 1)
   (0 6 3 4)
   scm> (decay a 5)
   (0 2 3 4)
   scm> (decay a 9)
   (0 0 1 4)

   (define (decay boxes rotten)













   )
   ```

```
(define (decay boxes rotten)
    (cond
        ((null? boxes) nil)
        ((< rotten (car boxes)) (cons (- (car boxes) rotten) (
          cdr boxes)))
        (else (cons 0 (decay (cdr boxes) (- rotten (car boxes)
          ))))
    )
)
```

6 SQL

Examine the table, `mentors`, depicted below.

Name	Food	Color	Editor	Language
Catherine	Thai	Purple	Notepad++	Java
Jamie	Pie	Green	Sublime	Java
Alina	Sushi	Orange	Emacs	Ruby
Kenny	Tacos	Blue	Vim	Python
Ethan	Ramen	Green	Vim	Python

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1. Write a query that has the same data, but alphabetizes the rows by name. (Hint: Use `order by`.)

```
Alina|Sushi|Orange|Emacs|Ruby
Catherine|Thai|Purple|Notepad++|Java
Ethan|Ramen|Green|Vim|Python
Jamie|Pie|Green|Sublime|Java
Kenny|Tacos|Blue|Vim|Python
```

```
select * from mentors order by name;
```

2. Write a query that lists the food and the color of every person whose favorite language is *not* Python.

```
Thai|Purple
Pie|Green
Sushi|Orange
```

```
select food, color
  from mentors
  where language != 'Python';

-- With aliasing
select m.food, m.color
  from mentors as m
  where m.language <> 'Python';
```

3. Write a query that lists all the pairs of mentors who like the same language. (How can we make sure to remove duplicates?)

```
Catherine|Jamie
Ethan|Kenny
```

```
select m1.name, m2.name
    from mentors as m1, mentors as m2
    where m1.language = m2.language and m1.name < m2.name;
```

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