Linked Lists and Midterm Review

Computer Science Mentors CS 61A

March 18 to March 20, 2019

1 Linked Lists

For each of the following problems, assume linked lists are defined as follows:

```
class Link:
    empty = ()
    def __init__(self, first, rest=empty):
        assert rest is Link.empty or isinstance(rest, Link)
        self.first = first
        self.rest = rest
```

To check if a `Link` is empty, compare it against the class attribute `Link.empty`:

```
if link is Link.empty:
    print('This linked list is empty!')
```

1. What will Python output? Draw box-and-pointer diagrams to help determine this.

```
>>> a = Link(1, Link(2, Link(3)))
>>> a.first

>>> a.first = 5
>>> a.first

>>> a.rest.first

>>> a.rest.rest.rest.rest.first


>>> a.rest.rest.rest = a
>>> a.rest.rest.rest.rest.first
```

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2. Write a function `skip`, which takes in a `Link` and returns a new `Link` with every other element skipped.

```
def skip(lst):
    """
    >>> a = Link(1, Link(2, Link(3, Link(4))))
    >>> a
    Link(1, Link(2, Link(3, Link(4))))
    >>> b = skip(a)
    >>> b
    Link(1, Link(3))
    >>> a
    Link(1, Link(2, Link(3, Link(4)))) # Original is unchanged
    """
    if ____________________________________________:

        ____________________________________________:

    elif __________________________________________:

        ____________________________________________

    ________________________________________________
```

3. Now write function `skip` by mutating the original list, instead of returning a new list. Do NOT call the `Link` constructor.

```
def skip(lst):
    """
    >>> a = Link(1, Link(2, Link(3, Link(4))))
    >>> skip(a)
    >>> a
    Link(1, Link(3))
    """
```

4. Write a function `reverse`, which takes in a `Link` and returns a new `Link` that has the order of the contents reversed.
   Hint: You may want to use a helper function if you're solving this recursively.

```
def reverse(lst):
    """
    >>> a = Link(1, Link(2, Link(3)))
    >>> b = reverse(a)
    >>> b
    Link(3, Link(2, Link(1)))
    >>> a
    Link(1, Link(2, Link(3)))
    """
```

2 Midterm Review

For each of the following problems, assume the Tree class is defined as follows: For the

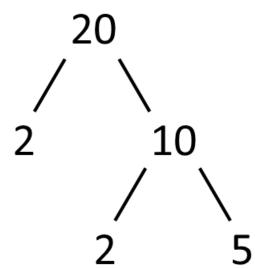
following problems, use this definition for the Tree class:

```
class Tree:
    def __init__(self, label, branches=[]):
        self.label = label
        self.branches = list(branches)

    def is_leaf(self):
        return not self.branches

    def __repr__(self):
        if self.branches:
            branch_str = ', ' + repr(self.branches)
        else:
            branch_str = ''
        return 'Tree({0}{1})'.format(self.label, branch_str)
```

1. Write a function that returns true only if there exists a path from root to leaf that contains at least `n` instances of `elem` in a tree `t`.

```
def contains_n(elem, n, t):
    """
    >>> t1 = Tree(1, [Tree(1, [Tree(2)])])
    >>> contains(1, 2, t1)
    True
    >>> contains(2, 2, t1)
    False
    >>> contains(2, 1, t1)
    True
    >>> t2 = Tree(1, [Tree(2), Tree(1, [Tree(1), Tree(2)])])
    >>> contains(1, 3, t2)
    True
    >>> contains(2, 2, t2) # Not on a path
    False
    """
    if n == 0:

        return True

    elif ________________________________________________:

        return __________________________________________

    elif ________________________________________________:

        return __________________________________________

    else:

        return __________________________________________
```

2. Define the function `factor_tree` which takes in a positive integer `n` and returns a factor tree for `n`. In a factor tree, multiplying the leaves together is the prime factorization of the root, `n`. See below for an example of a factor tree for `n = 20`.




```
def factor_tree(n):
    """
    >>> factor_tree(20)
    Tree(20, [Tree(2), Tree(10, [Tree(2), Tree(5)])])
    >>> factor_tree(1)
    Tree(1)

    for i in ______________________:

        if _________________________:

            return Tree(_____, _______________________________)

    __________________________________
```

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3. Draw the environment diagram that results from running the following code. If the code errors, draw the environment diagram up to the point that the error occurs.

```
earth = [0]
earth.append([earth])

def wind(fire, groove):
    fire[1][0][0] = groove
    def fire():
        nonlocal fire
        fire = lambda fantasy: earth.pop(1).extend(fantasy)
        return fire(groove)
    return fire()

sep = earth[1]
wind(earth, [earth[0]] + [earth.append(0)])
```