LISTS, ABSTRACTION, AND MIDTERM 1 REVIEW Solutions

COMPUTER SCIENCE MENTORS

February 15 - February 17, 2020

1 Lists

Lists Introduction:

Lists are a type of sequence, an ordered collection of values that has both length and the ability to select elements.

```
>>> lst = [1, False, [2, 3], 4] # a list can contain anything
>>> len(lst)
4
>>> lst[0] # Indexing starts at 0
1
>>> lst[4] # Indexing ends at len(lst) - 1
Error: list index out of range
```

We can iterate over lists using their index, or iterate over elements directly

```
for index in range(len(lst)):
        # do things
for item in lst:
        # do things
```

List comprehensions are a useful way to iterate over lists when your desired result is a list.

```
new_list2 = [<expression> for <element> in <sequence> if <
   condition>]
```

We can use **list splicing** to create a copy of a certain portion or all of a list.

```
new_list = lst[<starting index>:<ending index>]
copy = lst[:]
```

1. What would Python display? Draw box-and-pointer diagrams for the following:

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

```
[1, 2, 3]
```

```
>>> a[2]
```

3

```
>>> b = a
>>> a = a + [4, [5, 6]]
>>> a
```

```
[1, 2, 3, 4, [5, 6]]
```

```
>>> b
```

```
[1, 2, 3]
```

```
>>> c = a
>>> a = [4, 5]
>>> a
```

```
[4, 5]
```

```
>>> c
```

```
[1, 2, 3, 4, [5, 6]]
```

```
>>> d = c[3:5]
>>> c[3] = 9
>>> d
```

```
[4, [5, 6]]
```

```
>>> c[4][0] = 7
>>> d
```

```
[4, [7, 6]]
```

```
>>> c[4] = 10
>>> d
```

```
[4, [7, 6]]
```

```
>>> c
```

```
[1, 2, 3, 9, 10]
```

2. Draw the environment diagram that results from running the code.

```
def reverse(lst):
    if len(lst) <= 1:
        return lst
    return reverse(lst[1:]) + [lst[0]]

lst = [1, [2, 3], 4]
rev = reverse(lst)
```

https://goo.gl/6vPeX9

3. Write a function that takes in a list `nums` and returns a new list with only the primes from `nums`. Assume that `is_prime(n)` is defined. You may use a `while` loop, a `for` loop, or a list comprehension.

```
def all_primes(nums):

    result = []
    for i in nums:
        if is_prime(i):
            result = result + [i]
    return result

    List comprehension:
    return [x for x in nums if is_prime(x)]
```

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2 Abstraction

Data Abstraction Overview:

Abstraction allows us to create and access different types of data through a controlled, restricted programming interface, hiding implementation details and encouraging programmers to focus on how data is used, rather than how data is organized. The two fundamental components of a programming interface are a constructor and selectors.

1. Constructor: The interface that creates a piece of data; e.g. calling `c = car("Tesla")` creates a new car object and assigns it to the variable `c`.
2. Selectors: The interface by which we access attributes of a piece of data; e.g. calling `get_brand(c)` should return `"Tesla"`.

Through constructors and selectors, a data type can hide its implementation, and a programmer doesn't need to *know* its implementation to *use* it.

1. The following is an **Abstract Data Type (ADT)** for elephants. Each elephant keeps track of its name, age, and whether or not it can fly. Given our provided constructor, fill out the selectors:

```
def elephant(name, age, can_fly):
    """
    Takes in a string name, an int age, and a boolean
       can_fly.
    Constructs an elephant with these attributes.
    >>> dumbo = elephant("Dumbo", 10, True)
    >>> elephant_name(dumbo)
    "Dumbo"
    >>> elephant_age(dumbo)
    10
    >>> elephant_can_fly(dumbo)
    True
    """
    return [name, age, can_fly]
def elephant_name(e):

    return e[0]
def elephant_age(e):

    return e[1]
```

```python
def elephant_can_fly(e):

    return e[2]
```

2. This function returns the correct result, but there's something wrong about its implementation. How do we fix it?

```python
def elephant_roster(elephants):
    """
    Takes in a list of elephants and returns a list of
       their names.
    """
    return [elephant[0] for elephant in elephants]
```

`elephant[0]` is a Data Abstraction Violation (DAV). We should use a selector instead. The corrected function looks like:

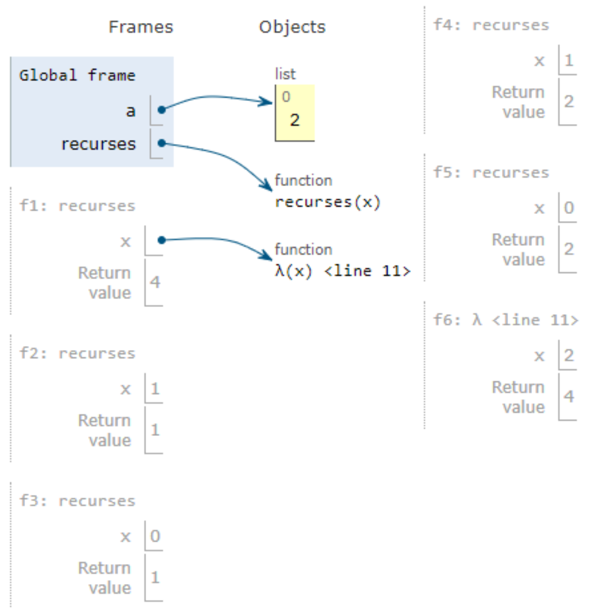
```python
def elephant_roster(elephants):
    return [elephant_name(elephant) for elephant in
       elephants]
```

3 Midterm Review - Environment Diagrams

1. **recurses**

   Fill in each blank in the code below so that its environment diagram is the following. You are not allowed to use operations like +, -, *, /, %, **max**, and **min**.

```
a = [0]
def recurses(x):
    if x == 0:
        return _______________
    elif type(x) == int:
        a[0] += x
        return _______________
    else:
        return _______________\
        ______________________
recurses(lambda x: x * x)
```



Solution

```
a = [0]
def recurses(x):
    if x == 0:
        return a[0]
    elif type(x) == int:
        a[0] += x
        return recurses(0)
    else:
        return x(recurses(recurses(1)))
recurses(lambda x: x * x)
```

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4 Midterm Review - Higher Order Functions

1. Make a lambda function, `make_interval()`, that takes in the upper and lower bound of an interval, and returns a function that takes in a value `x` and checks whether `x` is in the interval [`lower`, `upper`], inclusive.

```
>>> make_interval = ______________________________________
>>> in_interval = make_interval(-1, 2)
>>> in_interval(0)
True
>>> in_interval(61)
False
```

```
>>> make_interval = lambda lower, upper: lambda x: x <= upper
    and x >= lower
>>> in_interval = make_interval(-1, 2)
>>> in_interval(0)
True
>>> in_interval(61)
False
```

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2. Implement `make_alternator` which takes in two functions and outputs a function. The returned function takes in a number `x` and prints out all the numbers from 1 to `x`, applying `f` to the odd numbers and applying `g` to the even numbers before printing.

```
def make_alternator(f, g):
    """
    >>> a = make_alternator(lambda x: x * x, lambda x: x + 4)
    >>> a(5)
    1
    6
    9
    8
    25
    """

    def alternator(x):
        i = 1
        while i <= x:
            if i % 2 == 1:
                print(f(i))
            else:
                print(g(i))
            i += 1
    return alternator
```

5 Midterm Review - Recursion

1. A game is defined as follows: let `lst` be a list of coins, each coin represented as a positive integer (ex: 1, 5, 25, 10). Two players take turns claiming either the last coin in `lst`, or both the last *and* the second to last coin; after `lst` is exhausted, whichever player has the higher score wins. Fill in the function such that it returns the highest score that the first player (`player = True`) can get in this game if the second player (`player = False`) plays optimally.

   Hint: a player's choice is considered *optimal* if it maximizes their own score and minimizes the opponent's score.

```
def coin_game(lst, player):
    """
    >>> coin_game([1], True) // 1
    1
    >>> coin_game([1, 5, 25], True) // 25 + 5
    30
    >>> coin_game([1, 5, 10, 1, 5, 25], True) // 25 + 1 + 10
    36
    """
    if ______________________ and player:

        return ______________________________
    elif ____________________ and not player:

        return ______________________________
    else:
        if player:
            last = ______________________________________
            second_to_last = ____________________________

            return ________________________________________ \

                ______________________________________________
        else:
            return ________________________________________ \

                ______________________________________________
```

```
def coin_game(lst, player):
    if len(lst) <= 2 and player:
        return sum(lst)
    elif len(lst) <= 2 and not player:
        return 0
    else:
        if player:
            last = lst[len(lst) - 1]
            second_to_last = lst[len(lst) - 2]
            return max(coin_game(lst[:len(lst) - 1], not
               player) + last, coin_game(lst[:len(lst) - 2],
               not player) + last + second_to_last)
        else:
            return min(coin_game(lst[:len(lst) - 1]),
               coin_game(lst[:len(lst) - 2]))
```

6 Midterm Review - Tree Recursion

1. Implement the function `make_change`, which takes in a non-negative integer amount in cents `n` and returns the minimum number of coins needed to make change for `n` using 1-cent, 3-cent, and 4-cent coins.

```
def make_change(n):
    """
    >>> make_change(5) # 5 = 4 + 1 (not 3 + 1 + 1)
    2
    >>> make_change(6) # 6 = 3 + 3 (not 4 + 1 + 1)
    2
    """

    if ______________________:
        return 0

    elif ____________________:

        ____________________________________

    elif ____________________:

        ____________________________________

    else:

        ____________________________________
```

```
def make_change(n):
    if n == 0:
        return 0
    elif n < 3:
        return 1 + make_change(n - 1)
    elif n < 4:
        return 1 + min(make_change(n - 1), make_change(n - 3))
    else:
        return 1 + min(make_change(n - 1), make_change(n - 3),
            make_change(n - 4))
```

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7 Midterm Review - Lists

1. Write a list comprehension that accomplishes each of the following tasks.

   (a) Square all the elements of a given list, `lst`.

   ```
   [x ** 2 for x in lst]
   ```

   (b) Compute the dot product of two lists `lst1` and `lst2`. *Hint*: The dot product is defined as $\text{lst1}[0] \cdot \text{lst2}[0] + \text{lst1}[1] \cdot \text{lst2}[1] + \ldots + \text{lst1}[n] \cdot \text{lst2}[n]$. The Python **`zip`** function may be useful here.

   ```
   sum([x * y for x, y in zip(lst1, lst2)])
   ```

   (c) Return a list of lists such that `a = [[0], [0, 1], [0, 1, 2], [0, 1, 2, 3], [0, 1, 2, 3, 4]]`.

   ```
   a = [[x for x in range(y)] for y in range(1, 6)]
   ```

   (d) Return the same list as above, except now excluding every instance of the number 2: `b = [[0], [0, 1], [0, 1], [0, 1, 3], [0, 1, 3, 4]])`.

   ```
   b = [[x for x in range(y) if x != 2] for y in range(1, 6)]
   ```

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