# MUTABLE FUNCTIONS AND MIDTERM REVIEW 6

COMPUTER SCIENCE 61A

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## 1 Nonlocal

Until now, you've been able to access variables in parent frames, but you have not been able to modify them. The `nonlocal` keyword can be used to modify a variable in the parent frame outside the current frame. For example, consider `stepper`, which uses `nonlocal` to modify `num`:

```
def stepper(num):
    def step():
        nonlocal num  # declares num as a nonlocal variable
        num = num + 1 # modifies num in the stepper frame
        return num
    return step
```

However, there are two important caveats with `nonlocal` variables:

- **Global variables** cannot be modified using the `nonlocal` keyword.
- **Variables in the current frame** cannot be overridden using the `nonlocal` keyword.

## 1.1 Environment Diagrams

1. Draw the environment diagram for the code below:

```
def stepper(num):
    def step():
        nonlocal num
        num = num + 1
        return num
    return step

s = stepper(3)
s()
s()
```

2. Given the definition of `make_shopkeeper` below, draw the environment diagram.

```
def make_shopkeeper(total_gold):
    def buy(cost):
        nonlocal total_gold
        if total_gold < cost:
            return 'Go farm some more champions'
        total_gold = total_gold - cost
        return total_gold
    return buy

infinity_edge, zeal, gold = 3800, 1100, 3800
shopkeeper = make_shopkeeper(gold - 1000)
shopkeeper(zeal)
shopkeeper(infinity_edge)
```

## 1.2 Some Common Misconceptions

1. What is wrong with the following code?

```
a = 5
def another_add_one():
    nonlocal a
    a += 1
another_add_one()
```

2. What is wrong with the following code?

```
def adder(x):
    def add(y):
        nonlocal x, y
        x += y
        return x
    return add
adder(2)(3)
```

## 1.3 Fill in the Blank

1. The bathtub below simulates an epic battle between Finn and Kylo Ren over a populace of rubber duckies. Fill in the body of `ducky` so that all doctests pass.

```
def bathtub(n):
    """
    >>> annihilator = bathtub(500) # the force awakens...
    >>> kylo_ren = annihilator(10)
    >>> kylo_ren()
    490 rubber duckies left
    >>> finn = annihilator(-20)
    >>> finn()
    510 rubber duckies left
    >>> kylo_ren()
    500 rubber duckies left
    """
    def ducky_annihilator(rate):
        def ducky():









        return ducky
    return ducky_annihilator
```

# 2 Midterm Review

## 2.1 Environment Diagrams

1. Draw the environment diagram that results from executing the code below.

```
def this(x):
    return 2*that(x)

def that(x):
    x = y + 1
    this = that
    return x

x, y = 1, 2
this(that(y))
```

## 2.2 Lambdas

1. Fill in the blanks with one-line lambda expressions so that each call expression that follows returns 3.

```
>>> f1 = _____________________
>>> f1()
3

>>> f2 = _____________________
>>> f2()()
3

>>> f3 = _____________________
>>> f3()(3)
3

>>> f4 = _____________________
>>> f4()()(3)()
3
```

## 2.3 Lists and List Comprehension

1. Write a function that rotates the elements of a list to the right by $k$. Elements should not "fall off"; they should wrap around the beginning of the list. `rotate` should return a new list. To make a list of $n$ 0's, you can do this: `[0] * n`

```
def rotate(lst, k):
    """ Return a new list, with the same elements
        of lst, rotated to the right k.
    >>> x = [1, 2, 3, 4, 5]
    >>> rotate(x, 3)
    [3, 4, 5, 1, 2]
    """
```

2. Define a function `foo` that takes in a list `lst` and returns a new list that keeps only the even-indexed elements of `lst` and multiplies each of those elements by the corresponding index.

```
def foo(lst):
    """
    >>> x = [1, 2, 3, 4, 5, 6]
    >>> foo(x)
    [0, 6, 20]
    """

    return [_____]
```

3. Implement the functions `max_product`, which takes in a list and returns the maximum product that can be formed using nonconsecutive elements of the list. The input list will contain only numbers greater than or equal to 1.

```
def max_product(lst):
    """Return the maximum product that can be formed using lst
    without using any consecutive numbers
    >>> [10,3,1,9,2] # 10 * 9
    90
    """
```

## 2.4 Trees

1. An **expression tree** is a tree that contains a function for each non-leaf root, which can be either `'+'` or `'*'`. All leaves are numbers. Implement `eval_tree`, which evaluates an expression tree to its value. You may want to use the functions `sum` and `prod`, which take a list of numbers and compute the sum and product respectively.

```
def eval_tree(tree):
    """Evaluates an expression tree with functions as root
    >>> eval_tree(tree(1))
    1
    >>> expr = tree('*', [tree(2), tree(3)])
    >>> eval_tree(expr)
    6
    >>> eval_tree(tree('+', [expr, tree(4)]))
    10
    """
```