

# MUTABLE FUNCTIONS AND MIDTERM REVIEW 6

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COMPUTER SCIENCE 61A

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## 1 Nonlocal

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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.

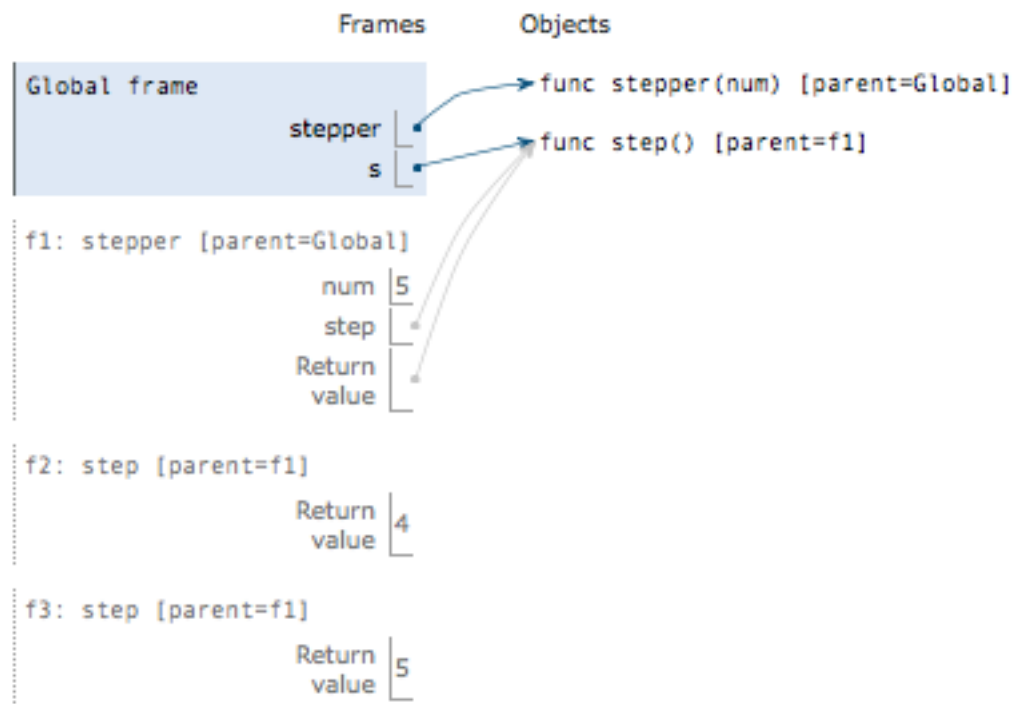
## 1.1 Environment Diagrams

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()
```

**Solution:**

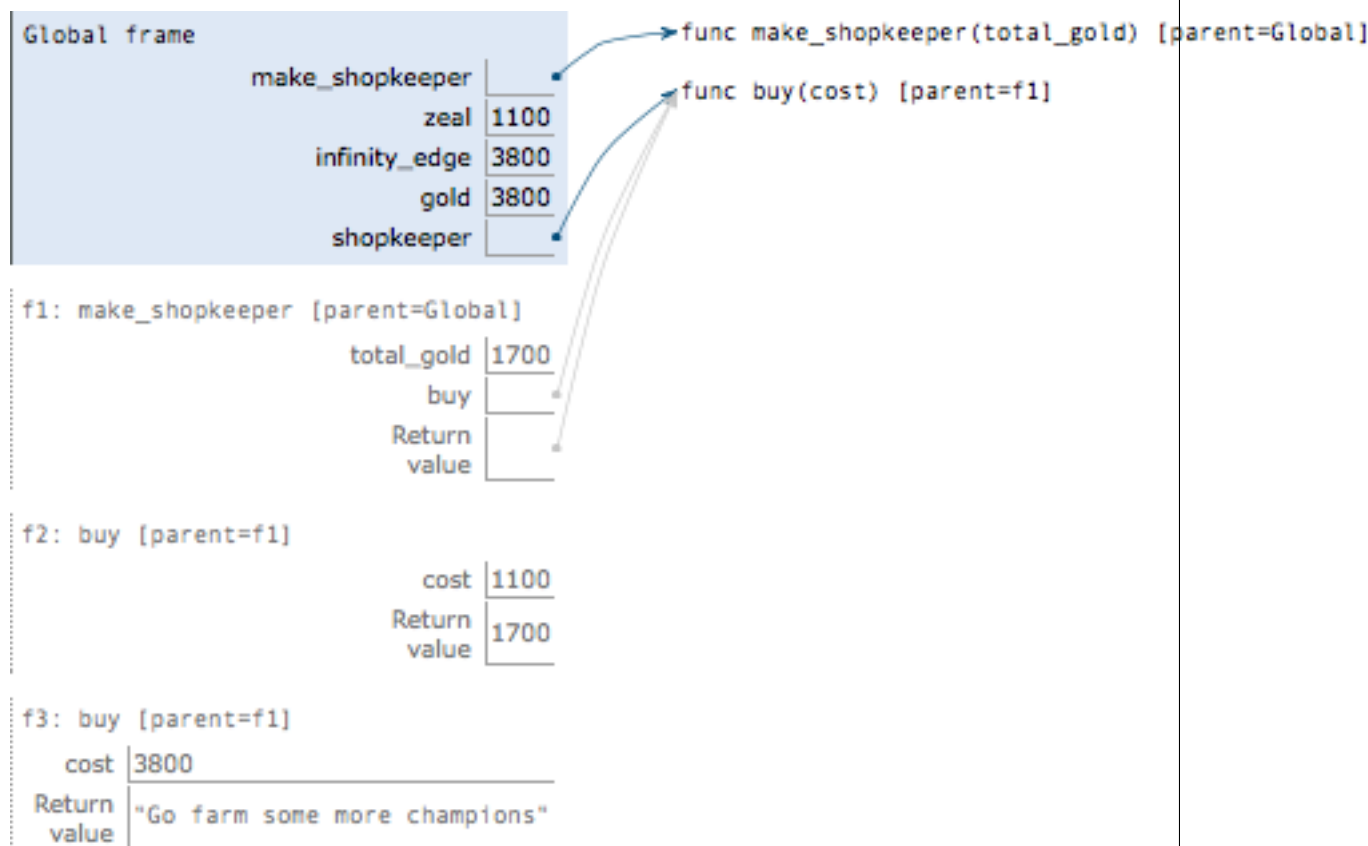


2. Given the definition of `make_shopkeeper` below, draw the environment diagram.

```
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)
```

**Solution:**



## 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()
```

**Solution:** Nonlocal cannot be used to modify variables in the global frame.

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)
```

**Solution:** There is no variable y defined in a parent frame, and y is already a local variable.

## 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():
```

**Solution:**

```
        nonlocal n
        n = n - rate
        print(n, 'rubber duckies left')

    return ducky
    return ducky_annihilator
```

## 2 Midterm Review

### 2.1 Environment Diagrams

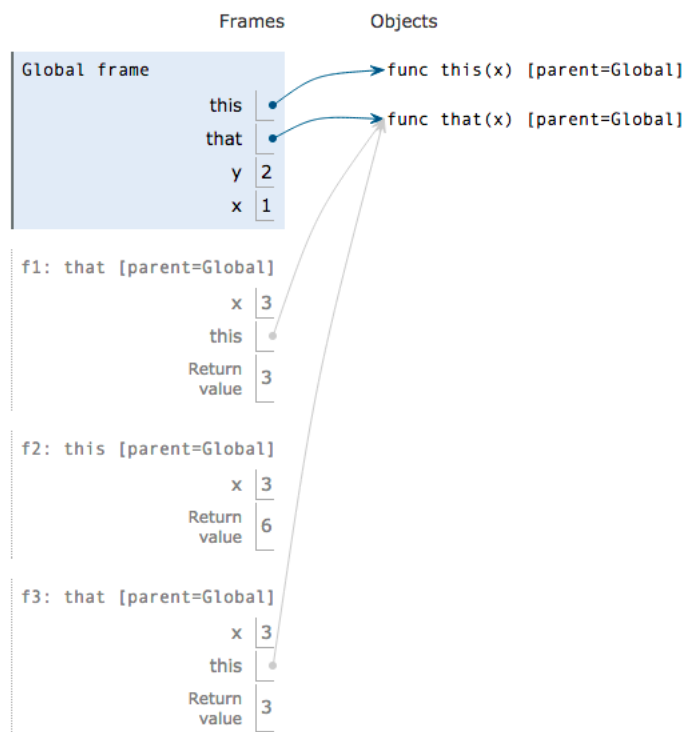
1. Draw the environment diagram that results from executing the code below.

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

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

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

**Solution:**



## 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
```

**Solution:**  
**lambda: 3**

```
>>> f2 = _____
>>> f2() ()
3
```

**Solution:**  
**lambda: lambda: 3**

```
>>> f3 = _____
>>> f3() (3)
3
```

**Solution:**  
**lambda: lambda x: x**

```
>>> f4 = _____
>>> f4() () (3) ()
3
```

**Solution:**  
**lambda: lambda: lambda x: lambda: x**

## 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]
"""
```

**Solution:**

```
n = len(lst)
ret = [0] * n
for i in range(n):
    j = (i + k) % n
    ret[j] = lst[i]
return ret
```

or

```
return lst[-k:] + lst[:-k]
```

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 [_____]
```

**Solution:**

```
return [i * lst[i] for i in range(len(lst)) if i % 2 ==
        0]
```

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
    """
```

**Solution:**

```
if lst == []:
    return 1
elif len(lst) == 1:
    return lst[0]
else:
    return max(max_product(lst[1:]), lst[0]*max_product(
        lst[2:]))
```



## 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  
"""
```

**Solution:**

```
if is_leaf(tree):  
    return entry(tree)  
args = [eval_tree(child) for child in children(tree)]  
if entry(tree) == '+':  
    return sum(args)  
elif entry(tree) == '*':  
    return prod(args)
```