CS 61A Structure and Interpretation of Computer Programs

Spring 2013

MIDTERM 1 SOLUTIONS

INSTRUCTIONS

- You have 2 hours to complete the exam.
- The exam is closed book, closed notes, closed computer, closed calculator, except one hand-written 8.5" × 11" crib sheet of your own creation and the official 61A midterm 1 study guide attached to the back of this exam.
- Mark your answers ON THE EXAM ITSELF. If you are not sure of your answer you may wish to provide a *brief* explanation.

Last name	
First name	
SID	
Login	
TA & section time	
Name of the person to your left	
Name of the person to your right	
All the work on this exam is my own. **(please sign)**	

For staff use only

Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Total
/12	/12	/6	/12	/8	/50

1. (12 points) Call Me Maybe

For each of the following call expressions, write the value to which it evaluates *and* what would be output by the interactive Python interpreter. The first two rows have been provided as examples.

Assume that you have started Python 3 and executed the following statements:

```
from operator import add, mul
def mulled(x, y):
    return mul(x, add(y, x))

def fauxpose(f, g):
    print('maybe')
    def h(x, y):
        f(x, y)
        return g(x, y)
    return h
```

Expression	Evaluates to	Interactive Output
`mulled(5, 5)`	50	50
`1/0`	Error	Error
`mulled(4, 1)`	20	20
`add(mulled(3, 2), print(4))`	Error	4 Error
`print(3, print(5, print(1)))`	None	1 5 None 3 None
`fauxpose(add, mul)(3, 2)`	6	maybe 6
`fauxpose(mul, print)(4, 1)`	None	maybe 4 1
`fauxpose(fauxpose, mulled)(2, 5)`	14	maybe maybe 14

2. (12 points) We Are All Environmentalists

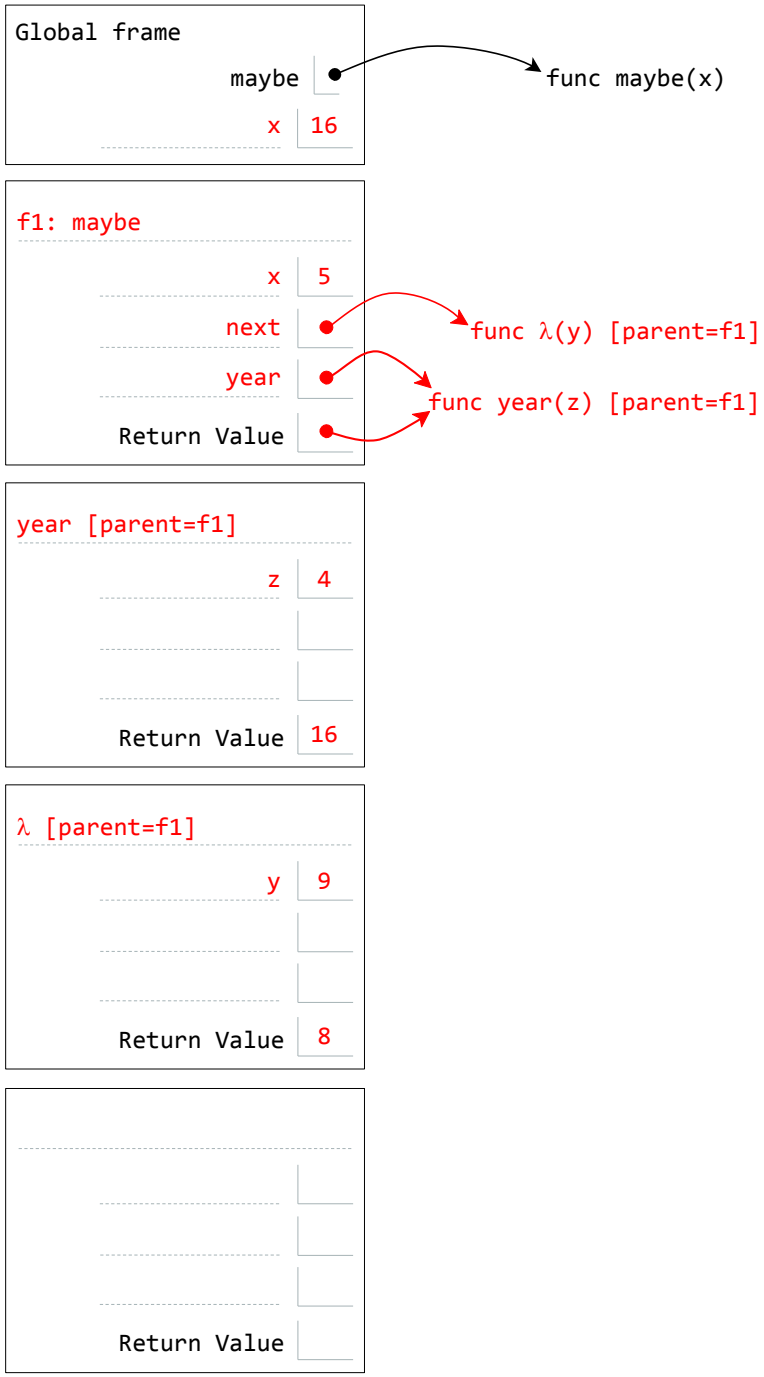
(a) (6 pt) Fill in the environment diagram that results from executing the code below until the entire program is finished, an error occurs, or all frames are filled. You need only show the final state of each frame. *You may not need to use all of the spaces or frames.*

A complete answer will:

- Add all missing names, labels, and parent annotations to all local frames.
- Add all missing values created during execution.
- Show the return value for each local frame.

```
def maybe(x):
    next = lambda y: y - 1
    x += 3
    def year(z):
        return next(z + x) * 2
    return year

x = maybe(2)(4)
```



(b) **(6 pt)** Fill in the environment diagram that results from executing the code below until the entire program is finished, an error occurs, or all frames are filled. You need only show the final state of each frame. *You may not need to use all of the spaces or frames.*

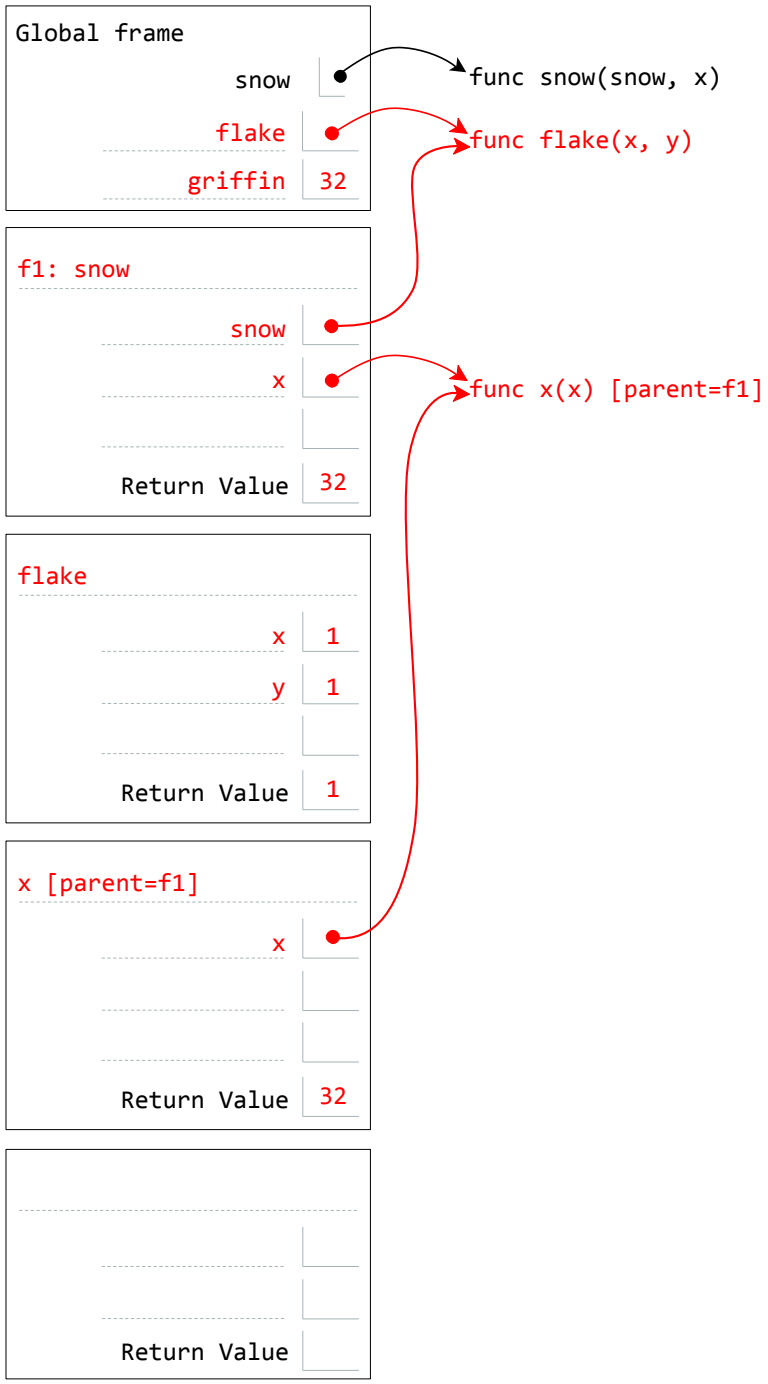
A complete answer will:

- Add all missing names, labels, and parent annotations to all local frames.
- Add all missing values created during execution.
- Show the return value for each local frame.

```
def snow(snow, x):
    if snow(x, x) == x:
        def x(x):
            return 32
        return x(x)
    else:
        return snow(snow, x)

def flake(x, y):
    return y + x - 1

griffin = snow(flake, 1)
```



3. (6 points) A Higher Order of Protection

Louis Reasoner is making a web application, and he wants to secure it. (Good for him!) One of the ways he wants to secure it is through checking to make sure that the user is an admin when it tries to visit certain confidential pages. So, being a silly programmer, he does the following.

```
def delete_everything(is_admin, request):
    if not is_admin:
        print('ERROR: not admin')
        return
    confirmation = do_bad_stuff(request) # BAD STUFF HAPPENS HERE
    return confirmation

def steal_credit_card_info(is_admin, request):
    if not is_admin:
        print('ERROR: not admin')
        return
    cc_info = hack_a_shaq(request) # DO SOME 1337 HAXORING
    return cc_info
```

However, Alyssa P. Hacker comes across this code, and realizes that there is a better way to do this using higher-order functions! She modifies the above as follows.

```
def delete_everything(request):
    confirmation = do_bad_stuff(request) # BAD STUFF HAPPENS HERE
    return confirmation
delete_everything = protect_me(delete_everything)

def steal_credit_card_info(request):
    cc_info = hack_a_shaq(request) # DO SOME 1337 H4X0RING
    return cc_info
steal_credit_card_info = protect_me(steal_credit_card_info)
```

Help her to complete the code by filling in the function below. The new code should provide the same functionality as the original code. For example, calling `delete_everything(True, my_request)` should have the same effect in both versions of the code.

You may leave lines blank if you do not need them.

```
def protect_me(fn):
    def wrapper(is_admin, request):
        if not is_admin:
            print('ERROR: not admin')
            return
        return fn(request)
    return wrapper
```

4. (12 points) Da Visors Provide Protection from Puns

An integer d is a *divisor* of another integer n if it evenly divides n, i.e. the remainder is 0 when dividing n by d. The divisors of n include 1 and n itself.

(a) Complete the function below to compute the number of positive divisors of a positive integer. Fill in the blanks. You may leave a line blank if you do not need it.

```
def num_divisors(n):
    """Computes the number of positive divisors of a positive integer.

    >>> num_divisors(4)    # 1, 2, and 4
    3
    """
    i, count = 1, 0
    while i <= n:
        if n % i == 0:
            count = count + 1
        i = i + 1
    return count
```

(b) Write a function that computes the sum of the positive divisors of a positive integer.

```
def sum_divisors(n):
    """Computes the sum of the positive divisors of a positive integer.

    >>> num_divisors(4)    # 1 + 2 + 4
    7
    """
    i = 1
    sum = 0
    while i <= n:
        if n % i == 0:
            sum += i
        i = i + 1
    return sum
```

(Continued on next page)

(c) A positive integer n is called *abundant* if the sum of its divisors (except n itself) is strictly larger than n. It is called *perfect* if the sum of its divisors (except n itself) is exactly equal to n. Finally, n is deficient if the sum of its divisors (excluding n) is strictly less than n. Write a function that returns the string `'abundant'` if the input `n` is abundant, `'perfect'` if `n` is perfect, and `'deficient'` if `n` is deficient. You may call `sum_divisors` and assume that it works correctly.

```
def describe(n):
    """Returns whether n is abundant, perfect, or deficient.

    >>> describe(4)    # 1 + 2 < 4
    'deficient'
    """
    divisors = sum_divisors(n) - n
    if divisors == n:
        return 'perfect'
    elif divisors > n:
        return 'abundant'
    else:
        return 'deficient'
```

5. (8 points) Lambda the Free

Assume that you have started Python 3 and executed the following statements:

```
square = lambda x: x * x

def muckluck(x):
    square(square(x))

def apply(f, x):
    return f(x)

def apply_many(f, x, n):
    while n > 0:
        x = f(x)
    return x

def wut(f):
    return lambda f: f(x)

def pair(x, y):
    return lambda k: x if k == 0 else y
```

For each of the following call expressions, write the value to which it evaluates. If the value is a function value, write FUNCTION. If evaluation causes an error, write ERROR. If evaluation would run forever, write FOREVER.

Expression	Evaluates to
`square`	Function
`muckluck(2)`	None
`apply(pair, 3)`	Error
`wut(square)`	Function
`pair(3, 4)(1)`	4
`pair(apply, square)(0)`	Function
`apply_many(square, 3, 0)`	3
`apply_many(square, 3, 2)`	Forever