CS 61A — Structure and Interpretation of Computer Programs

Fall 2011

Midterm Exam 2 Solutions

INSTRUCTIONS

- You have 2 hours to complete the exam.
- The exam is closed book, closed notes, closed computer, closed calculator, except a one-page crib sheet of your own creation and the two official 61A midterm study guides.
- 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	
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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	Total
/12	/10	/12	/16	/50

1. (12 points) Mutation and Non-Local Assignment

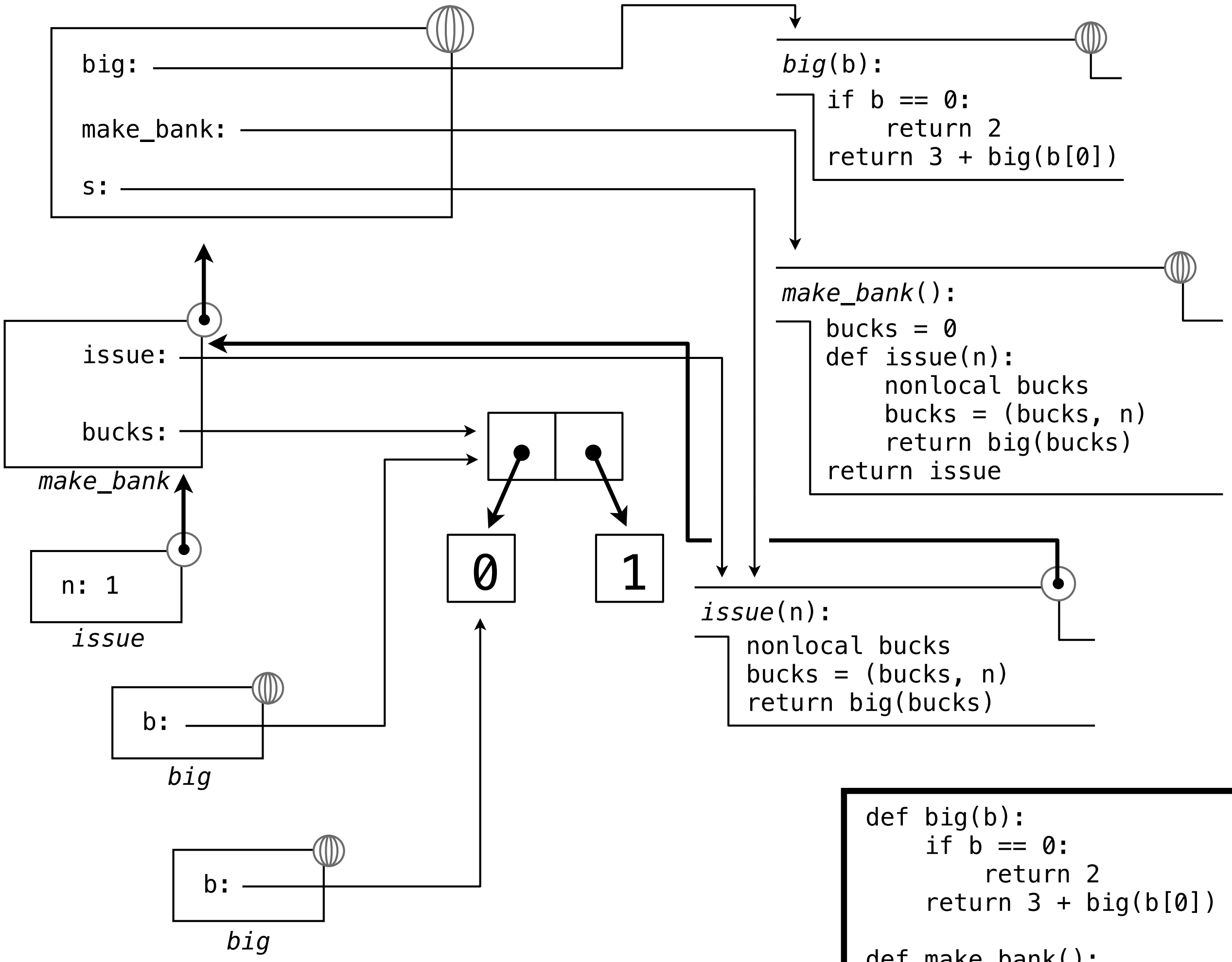
The Berkeley Banking Commune only accepts Berkeley Bucks. Each valid "buck" has a unique serial number. The bank tracks these serial numbers to make sure that nobody is photocopying its bucks.

(a) (4 pt) The higher-order function `make_deposit` returns a single-argument function `deposit` that takes a Python list of serial numbers. If all serial numbers ever deposited to that function are unique, `deposit` returns the number of bucks ever deposited. If a duplicate serial number is ever deposited, `deposit` will forever return the string `'Fraud'`. Fill in the `deposit` definition below. Do not include any unnecessary `nonlocal` statements. Do not include any additional `return` statements; one is provided for you.

```
def make_deposit():
    """Return a deposit function.

    >>> d1, d2 = make_deposit(), make_deposit()
    >>> d1([1, 3])
    2
    >>> d1([7, 7])
    'Fraud'
    >>> d1([8])
    'Fraud'
    >>> d2([2, 4, 6])
    3
    >>> d2([1, 3, 5])
    6
    >>> d2([4])
    'Fraud'
    """
    fraud = False
    contents = []
    def deposit(bucks):




        nonlocal fraud
        for buck in bucks:
            if buck in contents:
                fraud = True
            contents.append(buck)




        if fraud:
            return 'Fraud'
        return len(contents)
    return deposit
```

(b) **(6 pt)** Complete the environment diagram for the program in the box below. You **do not** need to draw an expression tree. A complete answer will:

- Complete all missing arrows. Arrows to the global frame can be abbreviated by small globes.
- Add all local frames created by applying user-defined functions.
- Add all missing names in frames.
- Add all **final** values referenced by frames. Represent tuple values using box-and-pointer notation.



```
def big(b):
    if b == 0:
        return 2
    return 3 + big(b[0])

def make_bank():
    bucks = 0
    def issue(n):
        nonlocal bucks
        bucks = (bucks, n)
        return big(bucks)
    return issue

s = make_bank()
s(1)
```

(c) **(2 pt)** After executing the program above, what would the expression `s(4)` evaluate to? If evaluating this expression causes an error, write "error." If evaluating this expression would take forever, write "infinite."

8

2. (10 points) List Processing

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

```
from operator import add

def baby(oh):
    baby = oh
    for b in baby:
        baby[0] = b
    return baby

bieber = ['om', 'nom', 'nom']
counts = [1, 2, 3]
nums = counts
nums.append(4)
```

For each of the following expressions, write the `repr` string (i.e., the string printed by Python interactively) of the value *to which it evaluates* in the current environment . If evaluating the expression causes an error, write "error." Any changes made to the environment by the expressions below *will affect* the subsequent expressions.

(a) (2 pt) `baby(bieber)`

```
['nom', 'nom', 'nom']
```

(b) (2 pt) `bieber[0:2]`

```
['nom', 'nom']
```

(c) (2 pt) `counts is nums`

```
True
```

(d) (2 pt) `counts is add([1, 2], [3, 4])`

```
False
```

(e) (2 pt) `tuple(map(baby, (nums, counts)))`

```
([4, 2, 3, 4], [4, 2, 3, 4])
```

3. (12 points) Object-Oriented Programming

(a) (2 pt) Louis Reasoner wants to define a Person class:

```
class Person(object):
    name = None
    def __init__(self, name):
        Person.name = name
    def greet(self):
        return "Hello, my name is " + self.name
```

Alyssa P. Hacker, sees a problem. Circle **all** appropriate criticisms of this implementation.

(A) Every Person's name will be the equal to the most recently created Person's name.

(B) Instantiating a Person will cause an error.

(C) Every Person's name will be `None`.

(D) Invoking `greet` on a person instance will cause an error.

(b) (2 pt) Consider the following simple class definition.

```
class Dog(object):
    def bark(self):
        print("woof!")
```

One day, while using this class, Louis Reasoner decides he wants his dog, Fido, to `bark` differently:

```
>>> fido = Dog()
>>> fido.bark = "bow wow!"
```

Ben Bitdiddle quickly points out that this won't work. "`bark` is supposed to be a method, not a string!" So Louis Reasoner attempts to reset the `bark` method to what it was before:

```
>>> fido.bark = Dog.bark
```

Ben replies, "I don't think your fix is right either!" Circle **all** appropriate statements about this final assignment statement.

(A) Executing this assignment statement will cause an error.

(B) After this assignment, invoking `fido.bark()` will cause an error.

(C) This assignment statement will have no effect at all.

(D) None of the above criticisms are valid.

(c) **(3 pt)** Cross out statements below so that the expression `N().r()` evaluates to 1.

```
class M(object):
    ~~p = 2~~   optional
    q = True
    def r(self):
optional if self.q:
            return self.p
        ~~return self.r() - 1~~

class N(M):
    p = 1
    ~~q = False~~
    ~~def r(self):~~
        ~~return self.p + 1~~
```

(d) **(2 pt)** Consider the following class definition using our implemented object system (below-the-line).

```
def make_foo_class():
    def __init__(self, a):
        self['set']('a', a)
    def someday(self):
        return "we will go " + str(attributes['a'])
    attributes = {'__init__': __init__,
                  'someday': someday,
                  'a': 42}
    return make_class(attributes, None)
Foo = make_foo_class()
```

Circle **all** equivalent class definitions below, among these options that use Python's built-in object system.

This one ↓

```
class Foo:
    a = 42
    def __init__(self, a):
        self.a = a
    def someday(self):
        return "we will go " + str(Foo.a)
```

```
class Foo:
    def __init__(self, a):
        self.a = a
    def someday(self):
        return "we will go " + str(self.a)
```

```
class Foo:
    a = 42
    def __init__(self, a):
        self.a = a
    def someday(self):
        return "we will go " + str(a)
```

(e) **(3 pt)** Louis Reasoner decides to modify the seventh line of the body of `make_instance` in his implementation of an object system. He also implements a `Person` class.

```
 1: def make_instance(cls):
 2:     def get_value(name):
 3:         if name in attributes:
 4:             return attributes[name]
 5:         else:
 6:             value = cls['get'](name)
 7:             return value # CHANGED FROM: return bind_method(value, instance)
 8:     def set_value(name, value):
 9:         attributes[name] = value
10:     attributes = {}
11:     instance = {'get' : get_value, 'set' : set_value}
12:     return instance
13:
14: def make_person_class():
15:     def __init__(self, name):
16:         self['set']('name', name)
17:         Person['set']('population', Person['get']('population') + 1)
18:     def greet(self):
19:         return "Hello, my name is " + self['get']('name')
20:     Person = make_class({'__init__': __init__,
21:                          'greet': greet,
22:                          'population': 0})
23:     return Person
```

Circle any of the following lines that will cause an error using this implementation.

```
>>> Person = make_person_class()
```

```
>>> yakko = Person['new']('yakko')
```

```
>>> yakko['get']('name')
```

This one ↓

```
>>> yakko['get']('greet')()
```

```
>>> yakko['get']('population')
```

4. (16 points) Defining Functions Without Iteration

ANSWER THESE QUESTIONS WITHOUT ANY FOR OR WHILE STATEMENTS

(a) (3 pt) Implement the function make_triangle_area that defines a relation among three connectors, the base b, height h, and area a of a triangle, so that $a = \frac{1}{2} \cdot b \cdot h$. You may assume that the functions make_connector, multiplier, and constant are defined for you as they were in lecture. The following results should be printed using your solution.

```
>>> a, b, h = [make_connector(n) for n in ('area', 'base', 'height')]
>>> make_triangle_area(a, b, h)
>>> a['set_val']('user', 75)
area: 75
>>> b['set_val']('user', 15)
base: 15
height: 10
```

```
def make_triangle_area(a, b, h):

    u, v = make_connector(), make_connector()
    multiplier(b, v, u)
    multiplier(u, h, a)
    constant(v, 0.5)
```

(b) (4 pt) Write a function overlap that takes two strings word1 and word2 and returns the maximum overlap between the end of word1 and the beginning of word2. *Assume both strings have the same length.*

```
>>> overlap('ball', 'ball')
'ball'
>>> overlap('pirate', 'teepee')
'te'
>>> overlap('fish', 'bowl')
''
```

```
def overlap(word1, word2):

    if word1 == word2:
        return word1
    return overlap(word1[1:], word2[:len(word2)-1])
```

ANSWER THESE QUESTIONS WITHOUT ANY FOR OR WHILE STATEMENTS

(c) **(3 pt)** Complete the function `listify` that takes as an argument an instance of either (i) the built-in `list` class or (ii) the user-defined `Rlist` class from lecture. `listify` returns a `list` containing the same elements as its argument. Use type dispatching and a call to `listify_rlist`.

```
>>> r = Rlist('He will knock', Rlist(3, Rlist('times')))
>>> s = ["fezzes", "are", "cool"]
>>> listify(r)
["He will knock", 3, "times"]
>>> listify(s)
["fezzes", "are", "cool"]

def listify_rlist(r, s):
    """Fill list s with the contents of Rlist r."""
    if r is not Rlist.empty:
        s.append(r.first)
        listify_rlist(r.rest, s)

def listify(seq):

    if type(seq) == list:
        return seq  # Also accepted: return list(seq)
    if type(seq) == Rlist:
        s = []
        listify_rlist(seq, s)
        return s
```

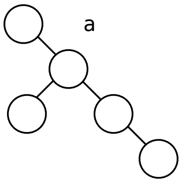
(d) **(2 pt)** Define a mathematical function $f(n)$ such that calling `listify(s)` on an `Rlist` instance `s` takes $\Theta(f(n))$ steps. Assume that `s` is an `Rlist` of length n and each element of `s` is itself an `Rlist` of length n. Assume that the `append` method for `list` takes a constant number of steps.

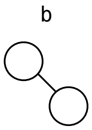
$f(n) = n$

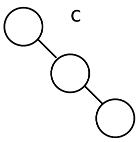
ANSWER THESE QUESTIONS WITHOUT ANY FOR OR WHILE STATEMENTS

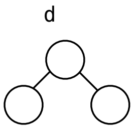
Consider the binary `Tree` class below, which has no entry attribute.

```
class Tree(object):
    """A binary tree with no entries."""
    def __init__(self, left=None, right=None):
        self.left = left
        self.right = right
a = Tree(None, Tree(Tree(), Tree(None, Tree())))
b = Tree(None, Tree())
c = Tree(None, Tree(None, Tree()))
d = Tree(Tree(),  Tree())
```









	(a,b)	(a,c)	(a,d)
pruned	True	True	False

(e) **(4 pt)** Write a function `pruned` that takes two `Tree` arguments `t1` and `t2` and returns whether `t2` is a pruned version of `t1`. `t2` is a pruned version of `t1` if all paths from the root of `t2` are also valid paths from the root of `t1`. A path is an ordered sequence of branch selections (e.g., `right, right, left`). Your base case(s) should compare an input to `None`.

```
def pruned(t1, t2):

    if t2 is None:
        return True
    if t1 is None:
        return False
    return pruned(t1.left, t2.left) and pruned(t1.right, t2.right)
```