CS 1110 Final Exam May 16, 2015

(Print Last Name)

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Write your name and NetID on every page.

Check that your exam has (14) pages counting this one.

In cases where you write code, you will lose points for ambiguous indentation.

If you write down more than one solution to a question, indicate which one you want us to grade. Otherwise your score will be dragged down by the worst solution.

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Problem 1	15 points	
Problem 2	5 points	
Problem 3	10 points	
Problem 4	10 points	
Problem 5	10 points	
Problem 6	10 points	
Problem 7	10 points	
Problem 8	5 points	
Problem 9	10 points	
Problem 10	15 points	

1 What do they Do?

(a) The specification in the following is incomplete:

```
def f(s):
    """
    PreC: s is a string.
    """
    t = s
    nullstring = ''
    for c in s:
        if s.count(c)>1:
           t = t.replace(c,nullstring)
    return t
```

Rewrite the specification so that it is complete:

(b) What is the output of the call `F([30,40,10,20])`?

```
def F(x):
    """
    PreCondition: x is a nonempty list of distinct ints
    """
    n = len(x)
    for k in range(n-1):
        if x[k]>x[k+1]:
            t = x[k]
            x[k] = x[k+1]
            x[k+1] = t
        print x
```

(c) The following code displays a 10,000 non-intersecting randomly colored disks. Comment on the expected number of displayed red disks, the expected number of displayed white disks, and the expected number of displayed blue disks. FYI, `randu(a,b)` returns a float that is randomly chosen from the interval $[a, b]$.

```
from random import  uniform as randu
from simpleGraphics import *
MakeWindow(101)
r = 0.3
for i in range(100):
   for j in range(100):
      x = float(i)
      y = float(j)
      p = randu(0,1)
      if p <= .1:
          DrawDisk(x,y,r,RED)
      elif p <= .4:
          DrawDisk(x,y,r,WHITE)
      else:
          DrawDisk(x,y,r,BLUE)
ShowWindow()
```

2 Functions and Lists

Complete the following function so that it performs as specified

```
def Trim(L):
   """ Returns a list of strings K that has four properties:
     (1) every entry in K is in L
     (2) every entry in L is in K
     (3) no entry in K is repeated
     (4) K  is sorted.

   L is not modified.

   PreC: L is a nonempty list of strings
   """
```

Thus, if `L = ['a','c','a','b','h','a','c']` then `['a','b','c','h']` is returned.

3 Boolean Operations

(a) Implement the following function so that it performs as specified.

```
def Q1(s1,s2,s3):
    """ Returns True if s1, s2, and s3 have a character in common and False otherwise.

    PreCondition: s1, s2, and s3 are nonempty strings
    """
```

(b) Assume that `B1`, `B2`, `B3`, `B4`, and `B5` are initialized Boolean variables. Rewrite the following code so that it does not involve any nested ifs. The rewritten code must be equivalent to the given code, i.e., it must render exactly the same output no matter what the value of the five initialized Boolean variables.

```
if B1:
    if B2:
        print 'A'
    elif B3:
        print 'B'
else:
    if B4 or B5:
        print 'C'
    else:
        print 'D'
```

4 While Loops

(a) Rewrite the following code so that it does the same thing but with while-loops instead of for-loops.

```
s = 'abcdefghijklmnopqrstuvwxyz'
for i in range(26):
    for j in range(0,i-1):
         for k in range(j,i):
              print  s[k] + s[j] + s[i]
```

(b) Implement the following function so that it performs as specified.

```
def OverBudget(A,M):
 """ Returns the smallest k so that sum(abs(A[0:k,0]))>=M, sum(abs(A[0:k,1]))>=M, and
 sum(abs(A[0:k,2]))>=M. If no such k exists, returns 0.
 PreC: A is an n-by-3 numpy array of ints. M is an int.
 """
```

To illustrate, suppose

$$A = \begin{bmatrix} 2 & 7 & 1 \\ 1 & 0 & 4 \\ 3 & 2 & 5 \\ 0 & 1 & 4 \\ 4 & 0 & 6 \end{bmatrix}$$

If `M = 3`, then the value returned should be 2. If `M = 10`, then the returned value should be 5. If `M = 100`, then the returned value should be 0. You are not allowed to use the built-in function `sum` or `for`-loops.

5 Recursion

Binary search is a divide and conquer process that can be use to determine whether or not a given value is an entry in a sorted list. Here is an informal, recursive illustration of the process applied to finding a name in a phone book assuming that there is one name per page:

```
Look-Up Process:
    if the phone book has one page
         Report whether or not  the name is on that page
    else
         Tear the phone book in half
         Apply the Look-Up Process to the relevant half-sized phonebook
```

Develop a recursive binary search implementation of the following function so that it performs as specified. You are not allowed to use the `in` operator.

```
def BinSearch(x,a,L,R);
   """Returns True if x in a[L:R+1] is True and False otherwise.

   Precondition: a is a length-n list of distinct ints whose entries are sorted from
   smallest to largest.  L and R are ints  that satisfy 0<=L<=R<n. x is an int with the
   property that a[L]<=x<=a[R].
   """
```

6 Function Execution

What is the output if the following Application Script is executed?

```
def F(a):
   b = True
   for k in range(len(a)):
       b = D(a,k) and b
   return b

def D(a,k):
   a[k] = a[k]-1
   return a[k] >= 0


if __name__ == '__main__':
  a = [1,2,3,4]
  print F(a)
  print a
  print F(a)
  print a
```

7 Short Answer

(a) Why is inheritance such an important aspect of object oriented programming?

(b) What does it mean to say that an operator like "+" is overloaded?

(c) The `numpy` module supports the addition of arrays. What does this mean?

8 Inverting a Dictionary

Implement the following function so that it performs as specified.

```
def Invert(D):
    """ Returns a dictionary that is obtained from D by swapping its keys and values.

    PreC: D is a dictionary with the property that every value is either a string or a number,
    and no values are repeated throughout the entire dictionary."""
```

Thus, if `D = {1:'x','z':4,'x':'z'}`, then the dictionary `{'x':1,4:'z', 'z':'x'}` is returned. You are not allowed to use the dictionary methods `keys` or `values`.

9 A Modified Energy Class

Consider the following modification of the class `Energy` that was part of A7:

```
class EnergyMod:
"""
  Name:  a string that is the name of the building
 Image:  a string that specifies the path of the building's jpeg image
E_rate:  a length-24 numpy array where E-Rate[k] is  the cost of electricity per
         unit of consumption during the kth hour of the day, k in range(24)
S_rate:  a length-24 numpy array where S-Rate[k] is  the cost of steam per
         unit of consumption during the kth hour of the day, k in range(24)
C_rate:  a length-24 numpy array where C-Rate[k] is  the cost of chilled water per
         unit of consumption during the kth hour of the day, k in range(24)
     A:  a 35040-by-3 numpy array that houses all the energy consumption snapshots.
         In particular, A[k,0], A[k,1], and  A[k,2] house the
         electricity, steam, and chilled water consumption during the kth 15-minute
         period of the year.
TS_dict: a 35040-item time stamp index dictionary. If ts is a valid STANDARD TIME
         time stamp and k is the value of TS_dict(ts), then  A[k,:] houses the
         consumption data associated with the interval named by ts.
"""
```

Notice that instead of a single consumption rate for each of the three energies we have a list of 24 rates, one for each hour in the day. ASSUME STANDARD TIME. And just to be clear about what we mean by "hour of the day", if a consumption reading is associated with time stamp `dd-MMM-2014-hh-mm`, then the relevant hour of the day is specified by the substring `hh`.

Implement a method `arbitraryBill(self,T1,T2)` for the `EnergyMod` class that returns the total cost of energy consumed by the building represented by `self` beginning with the interval specified by time stamp `T1` through the interval specified by the time stamp `T2`. As an example,

```
M = EnergyMod('Gates')
x = M.arbitraryBill('15-May-2014-08-00','16-May-2014-11-45')
```

would assign to `x` the total energy cost of running Gates Hall from 8AM May 15 up to noon May 16. You are allowed to use the function `Invert` from Problem 8.

10 Methods

Assume the availability of the following class.

```
class Fraction:
    """
    A class that can be used to represent fractions.

    Attributes:
        num: the numerator [int]
        den: the denominator [positive int]

        Invariant: num and den have no positive common factors larger than 1.
    """
    def __init__(self,p,q):
        """ Returns a Fraction Object that represents p/q in lowest terms.

        PreC p and q are ints and q is nonzero.
        """

    def lowestTerms(self):
        """ Updates self so that its numerator and denominator have no
        positive common factors larger than 1, i.e., the underlying
        fraction has been reduced to lowestterms.
        """
```

(a) Write a method `AddOne(self)` that updates `self` by adding one to the numerator and adding one to the denominator of the fraction represented by `self`.

(b) Consider the class

```
class pointFract:
    """
    A class that can be used to represent points whose
    x and y coordinates are fractions

    Attributes:
       x: x-coordinate [Fraction]
       y: y-coordinate [Fraction]

    """
    def __init__(self,F1,F2):
        """ Returns a Fraction Object that represents the point (F1,F2)

        PreC: F1 and F2 are Fractions
        """
```

Write a method `distToOrigin(self)` for this class that returns the distance of `self` to the origin. FYI, the distance of the point (a, b) to the origin is given by $\sqrt{a^2 + b^2}$. You may assume that `math.sqrt` is available.

(c) Consider the code

```
F1 = Fraction(1,2)
F2 = Fraction(3,4)
P1 = pointFract(F1,F2)
P2 = P1
F2 = F1
```

`P2` references a `pointFract` object. What are the coordinates of the point represented by that object? For full credit, you must draw a state diagram that fully depicts all the references and objects after the above five lines of code are executed. (You may use the back side of this sheet for your answer.)

Function Information

Function	What It Does
`len(s)`	returns an `int` that is the length of string `s`
`s.count(t)`	returns an `int` that is the number of occurrences of string `t` in string `s`
`s.find(t)`	returns an `int` that is the index of the first occurrence of string `t` in the string `s`. Returns -1 if no occurrence.
`s.replace(t1,t2)`	returns a string that is obtained from `s` by replacing all occurrences of `t1` with `t2`.
`floor(x)`	returns a float whose value is the largest integer less than or equal to the value of `x`.
`ceil(x)`	returns a float whose value is the smallest integer greater than or equal to the value of `x`
`int(x)`	If `x` has type `float`, converts its value into an `int`. If `x` is a string like '-123', converts it into an `int` like -123
`float(x)`	If `x` has type `int`, converts its value into a `float`. If `x` is a string like '1.23', converts it into a `float` like 1.23.
`str(x)`	Converts the value of `x` into a string.
`DrawDisk(x,y,r,c)`	Draws a circle with center (x, y), radius r and color c.
`x.append(y)`	adds a new element to the end of the list `x` and assigns to it the value referenced by `y`.
`deepcopy(x)`	creates a complete copy of the object that is referenced by `x`.
`sum(x)`	returns the sum of the values in list `x` assuming that all its entries are numbers.
`(m,n) = A.shape`	assigns the row and column dimensions of the numpy 2D array A to m and n resp.
`x.sort()`	alphabetizes the list of strings x.