CS 1110 Final Exam

(SOLUTION GUIDE)

May 16, 2015

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) Complete the specification in the following

```
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
```

5 points:

Returns a string obtained from s by deleting all characters that appear more than once

-1 if "return" is not mentioned

(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
```

5 points:

30 40 10 20
30 10 40 20
30 10 20 40

4 points
30 40 10 20
30 10 40 20

4 points
30 10 20 40

2 points for these 1-liners

30 10 40 20

30 10 10 20

10 20 30 40

40 30 20 10

(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()
```

5 points

1000 Red
3000 White
6000 Blue

5 points

10%
30%
60%

3 points

1000 Red
4000 White
5000 Blue

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.

5 point solution:

```
K = []                      1
for s in L:                 1
   if s not in K:           1          K.count(s) == 0 OK
                                       -1 for using find on a list
       K.append(s)          1

K.sort()                    1         -1 if either sort or return missing
return K
```

5 point point solution:

```
K = []                      1
for k in range(len(L)):                 1
   if L[k] not in K:        1          K.count(s) == 0 OK
                                       -1 for using find on a list
       K.append(L[k])       1

K.sort()                    1         -1 if either sort or return missing
retrun K
```

3 point solution:

```
K = L
for s in L:
   if s not in K:                   K.count(s) == 0 OK
       K.append(s)
K.sort()                          -1 if either sort or return missing
return K
```

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
    """
```

5 point solutions

```
    for c in s1:
        if c in s2 and c in s3:
            return True
    return False
```

```
for c1 in s1:
    for c2 in s2:
        for c3 in s3:
            if c1==c2 and c2==c3
                return True
return False
```

-2 if "or" instead of "and". -2 if "True" part is right but "False" part is not. And vice versa.

3 point solution:

```
    for c in s1:
        if c in s2 and c in s3:
            return True
        else:
            return False
```

1 point
No loop but some relevant Boolean expression
Note: It is possible to do this problem using find

(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 Booolean variables.

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

5 points

```
if B1 and B2:
    print 'A'
elif B1 and B3:
    print 'B'
elif (not B1) and (B4 or B5):
    print 'C'
elif (not B1):
    print 'D'
```

3 points for printing A and B correctly

2 points for printing C and D correctly

-2 if the not B1 is missing

3 points

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

)

Typical 1 point solution

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

anything like this that can have more than one line of output is a 1 point solution

There must be at least one relevant boolean expression to get 1 point

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]
```

5 points

```
s = 'abcdefghijklmnopqrstuvwxyz
i = 0
while i < 26:
    j = 0
    while j < i-1:
         k = j
         while k < i:
            print s[k] + s[j] + s[i]
            k+=1
         j += 1
    i += 1
```

3 points

```
s = 'abcdefghijklmnopqrstuvwxyz
i = 0
j = 0
k = 0
while i < 26:
    while j < i-1:
         while k < i:
            print s[k] + s[j] + s[i]
            k+=1
         j += 1
    i += 1
```

2 points

```
s = 'abcdefghijklmnopqrstuvwxyz
i = 0
j = 0
k = 0
while i < 26:
    while j < i-1:
         while k < i:
            print s[k] + s[j] + s[i]
            k += 1
            j += 1
            i += 1
```

1 point same as preceeding but no initialization
1 point same as preceeding but no updates

(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 point solution:

```
k = 0                                       1 point maintaining the loop counter k
s0 = 0
s1 = 0
s2 = 0                                      1 point for running sum initializations and updates
(m,n) = A.shape
while k < m:                                1 point for while loop condition
   s0 += abs(A[k,0])
   s1 += abs(A[k,1])
   s2 += abs(A[k,2])
   k +=1
   if  s0>=M and s1>=M and s2 >= M:         1 point for correct and-ing condition and return
        return k
return 0                                    1 point for the return 0 situation
```

5 point solution:

```
k = 0                                       1 point maintaining the loop counter k
s0 = 0
s1 = 0
s2 = 0                                      1 point for running sum initializations and updates
(m,n) = A.shape
OneSumShort = (s0<M or s1<M or S2<M)
while k < m and  OneSumShort:               2 points for while loop condition
   s0 += abs(A[k,0])
   s1 += abs(A[k,1])
   s2 += abs(A[k,2])

   OneSumShort = (s0<M or s1<M or S2<M)
   k +=1
if not OneSumShort:                         1 point for returning the right thing
    return k
else
    return 0
```

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].
   """
```

```
if R==L:                                    3 points
                                                    -2 for len(a)==1 instead of R==L
     return x = a[L]                                -1  for x in a[L,R+1]
                                                    -1  for return L
                                            -------------------------------------
else:
     mid = (L+R)/2                          2 points
                                                    -2 for (a[L]+a[R])/2
                                                    -2 for len(a)/2

                                             ------------------------------------
     if x <= a[mid]                          1 point
                                                    -1  for x <= mid
                                             ----
          return BinSearch(x,a,L,mid)       2 points
     else
                                             -------------------------
          return BinSearch(x,a,mid+1,R)     2 points
                                                    -1 if  "mid"  and not  "mid+1"
```

```
For very wrong solutions,
           1 point for a single if-else
           1 point if the if-part tries to deal with the base case
           1 point if the else part tries to come up with a half-sized problem
           1 point if there is a recursive Binsearch call and it recognizes
                  that BinSearch retruns a Boolean value
```

```
Better solution
  def BinSearch(x,a,L,R):
       if R==L:
           return true
       else:
           m = (L+R)/2
           if a[L]<=x<=a[m]:
               return BinSearch(x,a,L,m,)
           elif a[m+1]<=x<=a[R]:
               return BinSearch(x,a,m+1,R)
           else:
               return False
```

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
```

```
Fact: D(a,k) subtracts 1 from a[k] and returns True iff the
      modified  a[k] is nonnegative

Fact: F(a) subracts 1 from every entry in a and returns True
      iff every entry in the modified a is nonnegative


The first call to F modifies a to [0,1,2,3] and returns True.

The second call to F modifies a to [-1,0,1,2] and returns False

So the 10 point solutions are

                    True                        True, [0,1,2,3]
                    [0,1,2,3]                   False, [-1,0,1,2]
                    False
                    [-1,0,1,2]
8 points
                    True                        [0,1,2,3]
                    [0,1,2,3]                   True
                    True                        [-1,0,1,2]
                    [-1,0,1,2]                  False
5 points
                    True
                    [0,2,3,4]
                    True
                    [0,1,3,4]
3 points
                    True
                    [1,2,3,4]
                    True
                    [1,2,3,4]

In any of the above, if there are extra lines of output (as if there was a print statement
inside the functions) then -2

2 points if some good chit chat and output looks like

                     list
                     boolean
                     list
                     boolean
```

7 Short Answer

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

```
4 points for any of these

   With inheritance, it is legal for a method from an existing class
   to be applied to an object of the new class


2 point answers:

   Enables one to reuse software. Enables one to build on old software. Makes it
   easier to maintain software.
```

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

```
3 point answers:

The operation performed depends on the operands.


Thus, x+y may mean concatenation if
x and y are strings and addition if x and y are floats
```

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

```
3 point answers

If x and y are numerical arrays  of the same size, then x+y creates a new array of the
same size obtained by adding entries. (OK not to say "numerical")

An example like [1,2,3]+[4,5,6] = [5,7,9]
```

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`.

5 points

```
E = {}                          1
for d in D:                     1
   theKey = d                   1
   theValue = D[d]              1
   E[theValue] = theKey         1
return E
```

5 points

```
E = {}                          1
for d in D:                     1
   E[D(d)] = d                  3
retrun E
```

2 points

```
E = {}
for d in D:
   E.append(d)
retrun E
```

5 points

```
Keys = []
Values = []
for d in D:
    Keys.append(d)
    Values. append(D[d])
E = {}
for k in range(length(Keys)):
    E[Values[k]] = Keys[k]
return E
```

3 points If everything is OK but they overwrite D and that causes a screw up

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 time stamp and
         k is the value of TS_dict(ts), then  A[k,:] houses the consumption data
         associated with 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 `int(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` from time stamp `T1` up to 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.

```
def arbitraryBill(self,T1,T2):                  no points off if the def is missing
                                                ----------------------------------------

    D = Invert(self.TS_dict)                    no points off if Invert is inside loop
    total = 0
                                                ----------------------------------------

    k1 = self.TS_dict[T1]                         3 points for getting the loop range set up
    K2 = self.TS_dict[T2]                           -1 if TS_list
                                                    -1 if range(T1,T2)
    for k in range(T1,T2):                     ----------------------------------------

        TS = D[k]                                 2 points
                                                     -2 if TS = self.TS_List[k]  (There is nor TS_List)
                                                ----------------------------------------
        Hour = int(TS(12:14))                     2 points
                                                      no points off if they forget  int
                                                      -1 for incorrect slice (but 12:13 OK)
                                                ----------------------------------------
        E = self.E_rate[Hour]                     1 point for accessing the rate lists
        S = self.S_rate[Hour]
        C = self.C_rate[Hour]
                                                ------------------------
        Total += E*self.A[k,0] +                  2 points
                 S*self.A[k,1] +                        1 for correct combo of A-entries
                 C*self.A[k,1]                          1 for correct running sum mechanics


-1 if they do not use the self. notation
```

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 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 are
        reduced to lowest terms.
        """
```

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

```
5 points                          3 points               2 points

    def AddOne(self):             def AddOne(self):      def AddOne(self):
        self.num += 1                  self.num += 1          p = self.get_num() + 1
        self.den += 1                  self.den += 1          q = self.get_den() +1
        self.lowestTerms()                                    return Fraction(p,q)

At most -1 for syntax errors like
                                   p.Fraction(q)      instead of  Fraction(p,q)
                                   lowestTerms(self)  instead of  self.lowestTerms()

No points of if they leave off the   def AddOne(self) header
```

(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.

5 point solutions

```
    distToOrigin(self):
        F1 = self.x                              1
        xfloat = float(F1.num)/float(F1.den)     1
        F2 = self.y                              1
        yfloat = float(F2.num)/float(F2.den)     1
        d = math.sqrt(xfloat**2 + yfloat**2)
        return d                                 1

    distToOrigin(self):
        xfloat = float(self.x.num)/float(self.x.den)     2
        yfloat = float(self.y.num)/float(self.y.den)     2
        return math.sqrt(xfloat**2 + yfloat**2)          1
```

3 point solution

```
    distToOrigin(self):
        a = self.x                           1
        b = self.y                           1
        return math.sqrt(a**2 + b**2)        1
```

2 point solution

```
    distToOrigin(self):
        a = self.F1                          1
        b = self.F2
        return math.sqrt(a**2 + b**2)        1
```

-1 if forget to use float

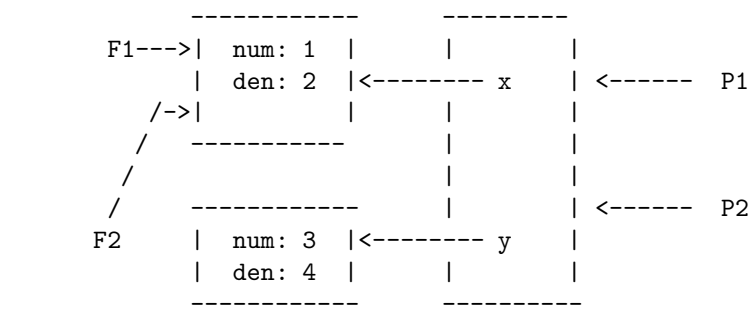
-1 (max) if syntax mistake like self(x)

(c) Consider the code

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

`P2` references a `pointFraction` 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.

`P2 represents the point (1/2,3/4)`



`2 points for correct point.` `2pts: (.50,.75)` `1pt: (.50,.50)`

`3 points for state diagram.` `1 point for showing 3 objects.`
`1 point for arrows from P1, P2, F1 and F2`
`1 point for arrows from x and y`

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()`	modifies the list of numbers x so that its entries range from smallest to largest