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CSCI 121

Handout #62
December 5, 2018

Practice Final Examination #2

Review session: **Friday, December 7, 3:10–4:30 P.M. (Psychology 105)**

Scheduled final: **Monday, December 10, 1:00–4:00 P.M. (Psychology 105)**

Problem 1—Short answer (10 points)

1a) Suppose that the function **conundrum** is defined as follows:

```
def conundrum():
    array = [ ]
    for i in range(13):
        array.append(0)
        for j in range(i, 0, -1):
            array[j] += j
    return array
```

If you look at the code, you'll see that the function appends a new value onto the array for every value between 0 and 12, which means that the array will eventually contain 13 elements with indices ranging from 0 to 12. Work through the function carefully and indicate the value of each of the elements in the array returned by a call to **conundrum**:

0	1	2	3	4	5	6	7	8	9	10	11	12

1b) What value is printed if you call the function **example** in the following code:

```
class MyClass():

    def __init__(self, x):
        def myFunction(y):
            return 2 * x + y
        self.myFunction = myFunction

    def test(self, x):
        return self.myFunction(x + 6)

def example():
    value = MyClass(14)
    print(value.test(8))
```

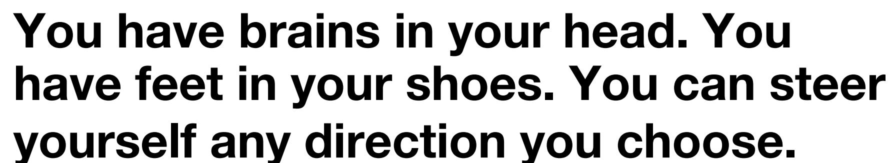
Problem 2—Simple graphics (15 points)

Programs like Microsoft Word make it possible to insert text inside a rectangular frame called a ***text box.*** Once you have created the text box, you can position it anywhere in the document so that it stays together as a unit. You can build much the same facility for the Portable Graphics Library by creating a `GCompound` that represents a text box.

Your task in this problem is to write a function `createTextBox(lines, font)` that takes an array of lines and a font specification and then returns a `GCompound` that displays the lines in the specified font enclosed in a rectangular frame. As an example, you could use the following code to create a text box containing a useful bit of wisdom drawn from Dr. Seuss's *Oh, the Places You'll Go!*:

```
SEUSS = [
    "You have brains in your head. You",
    "have feet in your shoes. You can steer",
    "yourself any direction you choose."
]
gw.add(createTextBox(SEUSS, "24px 'Sans-Serif'"), 50, 50)
```

This code draws the following text box with its upper left corner at (50, 50):

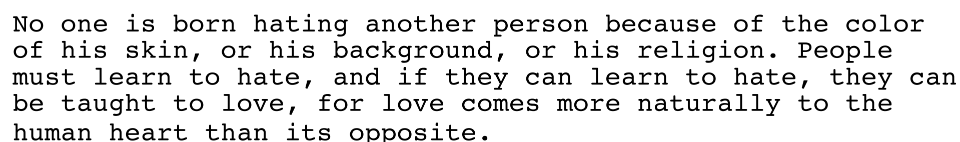


The quote is presented over three lines, where each line is a `GLabel` set in the specified font. The height of the text box scales with the number of lines, and the width of the rectangle is chosen so that the widest of three lines fits within it. The text is separated from the enclosing frame by a margin of 10 pixels on each side, which is given by the constant `TEXT_BOX_MARGIN`.

As another example, the following code snippet:

```
MANDELA = [
   "No one is born hating another person because of the color",
   "of his skin, or his background, or his religion. People",
   "must learn to hate, and if they can learn to hate, they can",
   "be taught to love, for love comes more naturally to the",
   "human heart than its opposite."
]
gw.add(createTextBox(MANDELA, "12px bold 'Monospaced'"), 50, 250)
```

would wrap a larger text box around Nelson Mandela's famous quote from his 1994 autobiography, *Long Walk to Freedom,* like this:

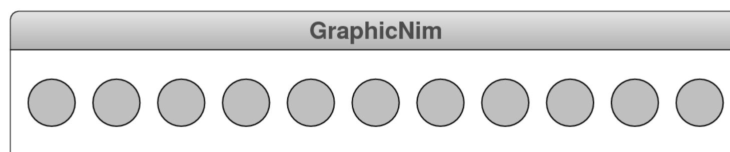


Problem 3—Interactive graphics (15 points)

In Eric's lecture on machine learning, one of the examples was a program that played a simple game called ***Nim.*** In the version of Nim described in class, two players start with a pile of 11 coins on the table between them. The players then take turns removing 1, 2, or 3 coins from the pile. The player who is forced to take the last coin loses. The point of the class example was to show how recursive backtracking can play a perfect game. In this problem, your task is to implement the game graphically, which is easiest to do in two steps:

Step 1.

Write the code necessary to create a graphical display in which a line of coins is arranged horizontally on the screen, like this:



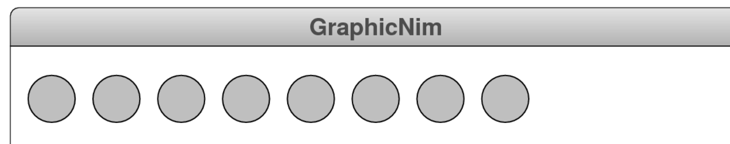
In creating this display, you should make use of the following constants:

```
GWINDOW_WIDTH = 496
GWINDOW_HEIGHT = 75
N_COINS = 11
COIN_SIZE = 32
COIN_FILL_COLOR = "LightGray"
```

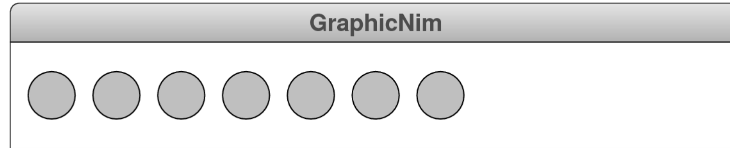
It is useful to note that these constants specify the number of coins and the coin size, but not the spacing. You should position the coins so that the space between each coin and between the coins and the border of the window is divided equally after determining how much space is left after displaying the coins. The line of coins should be centered both horizontally and vertically in the window. Each coin should be outlined in black and use the light-gray fill color specified by the constant `COIN_FILL_COLOR`.

Step 2.

The second part of the problem consists of making it possible to take coins away. Add the necessary code so that if the user clicks the mouse in one of the last three coins in the row, those coins disappear. For example, if the user clicks on the third coin from the right end, the program should respond by removing the last three coins from the display, like this:



If the user then clicks on the rightmost coin, only that coin should go away:



If the mouse click does not occur inside a coin or if the coin is not one of the last three in the row, that click should simply be ignored.

In order to solve this problem, you will need to store the `GOval` objects in a list so that you can keep track of their order. When a mouse click occurs, your program needs to find the object at that mouse location (if any) and see whether it is one of the last three elements in the list. If so, your program should remove that element and any following elements from both the list and the window.

Problem 4—Strings (15 points)

The table of contents for a book typically consists of a list of chapter titles along the left margin of a page and the corresponding page numbers along the right. To make it easier for your eye to match up the chapter and page, the usual approach is to tie the two visually with a line of dots called a ***leader.*** Using this style, the entries for the first eight chapters in the Python textbook look like this:

```
1. Introducing Python . . . . . . . . . . . . . . . . . .   1
2. Control Statements . . . . . . . . . . . . . . . . . .  41
3. Simple Graphics  . . . . . . . . . . . . . . . . . . .  79
4. Functions  . . . . . . . . . . . . . . . . . . . . . . 117
5. Writing Interactive Programs . . . . . . . . . . . . . 155
6. Strings  . . . . . . . . . . . . . . . . . . . . . . . 195
7. Lists  . . . . . . . . . . . . . . . . . . . . . . . . 231
8. Algorithmic Analysis . . . . . . . . . . . . . . . . . 269
```

Write a function

```
def createTocEntry(title, page)
```

that takes a chapter title (which includes the chapter number in these examples) and the page number on which that chapter begins. Your function should returns a string formatted as an entry for the table of contents. Thus, if you were to call

```
createTocEntry("6. Strings", 195)
```

the function should return the following string:

```
"6. Strings  . . . . . . . . . . . . . . . . . . . . . . . 195"
```

In generating this string, your function should adhere to the following guidelines:

- The strings returned by `createTocEntry` should all have the same length, which is given by the constant `TOC_LINE_LENGTH`. In the earlier examples, `TOC_LINE_LENGTH` has the value 60.
- The chapter title must appear at the beginning of the result string and must be separated from the first dot in the leader by at least one space.

- The page number must appear at the end of the result string so that the last character of each page number will line up at the column specified by **`TOC_LINE_LENGTH`**. Like the title, the page number must be separated from the last dot in the leader by at least one space.
- The leader itself is composed of alternating spaces and dots, indicated by the period character `"."`. Moreover, the dots must be arranged so that they line up vertically. If you simply start the leader one space after the chapter title, the dots would appear to weave back and forth on the page as illustrated by the following lines:

```
1. Introducing Python . . . . . . . . . . . . . . . . . . .  1
2. Control Statements . . . . . . . . . . . . . . . . . . . . 41
3. Simple Graphics . . . . . . . . . . . . . . . . . . . . .  79
```

  An easy way to ensure that the dots are aligned correctly is to add an extra space after chapter titles—like `"3. Simple Graphics"`—with an even number of characters but not after those—like `"2. Control Statements"`—with an odd number.
- You may assume that the chapter title and page number fit in **`TOC_LINE_LENGTH`** character positions and need not make your function handle the situation when the title is too long for the line.

Problem 5—Arrays (10 points)

Write a function

```
def findFirstDuplicate(array):
```

that returns the first element in **`array`** that appears more than once. If there is no duplicated value in the array, **`findFirstDuplicate`** should return the value **`None`**.

The following examples illustrate the values that **`findFirstDuplicate`** should return:

```
findFirstDuplicate([ 1, 2, 3, 4, 3, 2 ]) → 2
findFirstDuplicate([ "a", "b", "c", "d", "c" ]) → "c"
findFirstDuplicate([ 1, 2, 3, 4, 5, 6, 7 ]) → None
findFirstDuplicate([ ]) → None
```

Problem 6—Recursive functions (10 points)

Problem 3 on Assignment #2 (Handout #5) introduced the ***hailstone sequence*** from mathematics. If you start with a positive integer n, you can compute the terms in the hailstone sequence by repeatedly executing the following steps:

- If n is equal to 1, you've reached the end of the sequence and can stop.
- If n is even, divide it by two.
- If n is odd, multiply it by three and add one.

The ***hailstone number*** for a positive integer n is the number of steps it takes for this process to reach 1. Thus, the hailstone number for 1 is 0, and the hailstone number for 7 is 16, which is the number of arrows in the following sequence:

$$7 \rightarrow 22 \rightarrow 11 \rightarrow 34 \rightarrow 17 \rightarrow 52 \rightarrow 26 \rightarrow 13 \rightarrow 40 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1$$

Write a recursive function

```
def hailstoneNumber(n):
```

that returns the hailstone number for **n**. For example, calling **hailstoneNumber(7)** should return the value 16. Similarly, calling **hailstoneNumber(5)** should return 5 because there are five arrows in the sequence

$5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1$

Calling **hailstoneNumber(1)** should return 0, because it takes that no steps at all to reach 1.

Remember that your function—along with any helper functions you write—must operate **recursively** and may use no iterative constructs such as **while** or **for**.

Problem 7—Defining classes (10 points)

In writing the ImageShop project, one of the functions that you needed to perform for several of the operations is creating a pixel array for a given width and height. Although it is easy to write a function for this purpose—and many of you did just that—you can also define a **PixelArray** class that extends the built-in Python class **list** so that it represents a two-dimensional pixel array. The constructor for **PixelArray** should take two parameters in addition to the required **self** parameter that specify the width and height of the pixel array. When the constructor returns, the object should be initialized to a list of lists where the outer list contains the rows and the inner lists contains the individual pixel values. Your class definition does not need to define any methods other than the constructor.

For example, calling **PixelArray(4, 3)** creates a two-dimensional array with the following contents:

```
[ [ 0, 0, 0, 0 ], [ 0, 0, 0, 0 ], [ 0, 0, 0, 0 ] ]
```

Remember that each row must be allocated independently to avoid having the rows be copies of the same row.

The advantage of defining **PixelArray** as a subclass of **list** is that doing so means that objects of type **PixelArray** automatically implement all the standard functions that apply to Python lists.

Problem 8—Python data structures (15 points)

At this point in the semester, the data structures you know best are the ones from the Adventure assignment, which drive the operation of the **run** method in **AdvGame**. You could, of course, do something else with those same structures. For example, you might want to write a function that would generate a cheat sheet for solving a particular Adventure game by listing all the objects that are available in the game along with where they are located at the beginning of the game and where they are required to traverse a locked passage.

Your job in this problem is to implement the function

```
def printCheatSheetForObjects(rooms, objects)
```

that takes two parameters, both of which are dictionaries:

1. The dictionary **rooms**, in which the keys are the room names and the values are the **AdvRoom** objects. As discussed in Milestone #7, you may assume that the **AdvRoom** class exports a method called **getPassages**, which returns a list of tuples containing the direction name, the destination room, and the object (possibly **None**) that unlocks the passage.
2. The dictionary **objects**, in which the keys are the object names and the values are the corresponding **AdvObject** structures.

Your function should display a cheat sheet showing the name of each object, its short description in parentheses, and the short description of its initial location (or the word **"PLAYER"** for objects that the player is initially holding). After each object in the list, the **printCheatSheetForObjects** function should go through the rooms data structure and print out a line for each entry in which that object acts as a key to a locked passage.

For example, if you call the function for the rooms and objects for the **Small** adventure, your implementation of **printCheatSheetForObjects** should generate the following output:

AdventureCheatSheet

```
KEYS (a set of keys): Inside building
  Needed for DOWN from Outside grate
LAMP (a brightly shining brass lamp): Beneath grate
  Needed for XYZZY from Inside building
  Needed for WEST from Cobble crawl
ROD (a black rod with a rusty star): Debris room
WATER (a bottle of water): PLAYER
```