CS 61A Summer 2022

Mutability, OOP

Discussion 5: July 7, 2022 Solutions

##Walkthrough Videos

Feel free to try these problems on the worksheet in discussion or on your own, and then come back to reference these walkthrough videos as you study.

> To see these videos, you should be logged into your berkeley.edu email.
>
> **Note:** These videos are from a past semester and are not updated to reflect any changes (variable names may be different). Also note that we unfortunately do not have a walkthrough video available for "Add This Many."

Mutability

Some objects in Python, such as lists and dictionaries, are **mutable**, meaning that their contents or state can be changed. Other objects, such as numeric types, tuples, and strings, are **immutable**, meaning they cannot be changed once they are created.

Let's imagine you order a mushroom and cheese pizza from La Val's, and they represent your order as a list:

```
>>> pizza = ['cheese', 'mushrooms']
```

With list mutation, they can update your order by mutate `pizza` directly rather than having to create a new list:

```
>>> pizza.append('onions')
>>> pizza
['cheese', 'mushrooms', 'onions']
```

Aside from `append`, there are various other list mutation methods:

- `append(el)`: Add `el` to the end of the list. Return `None`.
- `extend(lst)`: Extend the list by concatenating it with `lst`. Return `None`.
- `insert(i, el)`: Insert `el` at index `i`. This does not replace any existing elements, but only adds the new element `el`. Return `None`.
- `remove(el)`: Remove the first occurrence of `el` in list. Errors if `el` is not in the list. Return `None` otherwise.
- `pop(i)`: Remove and return the element at index `i`.

We can also use list indexing with an assignment statement to change an existing element in a list. For example:

```
>>> pizza[1] = 'tomatoes'
>>> pizza
['cheese', 'tomatoes', 'onions']
```

Q1: WWPD: Mutability

What would Python display? In addition to giving the output, draw the box and pointer diagrams for each list to the right.

```
>>> s1 = [1, 2, 3]
>>> s2 = s1
>>> s1 is s2
```

True

```
>>> s2.extend([5, 6])
>>> s1[4]
```

6

```
>>> s1.append([-1, 0, 1])
>>> s2[5]
```

[-1, 0, 1]

```
>>> s3 = s2[:]
>>> s3.insert(3, s2.pop(3))
>>> len(s1)
```

5

```
>>> s1[4] is s3[6]
```

True

```
>>> s3[s2[4][1]]
```

1

```
>>> s1[:3] is s2[:3]
```

False

```
>>> s1[:3] == s2[:3]
```

True

```
>>> s1[4].append(2)
>>> s3[6][3]
```

2

Q2: Add This Many

Write a function that takes in a value`x`, a value `el`, and a list `s`, and adds `el` to the end of `s` the same number of times that `x` occurs in `s`. **Make sure to modify the original list using list mutation techniques.**

```
def add_this_many(x, el, s):
    """ Adds el to the end of s the number of times x occurs in s.
    >>> s = [1, 2, 4, 2, 1]
    >>> add_this_many(1, 5, s)
    >>> s
    [1, 2, 4, 2, 1, 5, 5]
    >>> add_this_many(2, 2, s)
    >>> s
    [1, 2, 4, 2, 1, 5, 5, 2, 2]
    """
    count = 0
    for element in s:
        if element == x:
            count += 1
    while count > 0:
        s.append(el)
        count -= 1
```

Two alternate solutions involve iterating over the list indices and iterating over a copy of the list:

```
def add_this_many_alt1(x, el, s):
    for i in range(len(s)):
        if s[i] == x:
        s.append(el)
```

```
def add_this_many_alt2(x, el, s):
    for element in list(s):
        if element == x:
        s.append(el)
```

OOP

Object-oriented programming (OOP) is a programming paradigm that allows us to treat data as objects, like we do in real life.

For example, consider the **class** `Student`. Each of you as individuals is an **instance** of this class.

Details that all CS 61A students have, such as `name`, are called **instance variables**. Every student has these variables, but their values differ from student to student. A variable that is shared among all instances of `Student` is known as a **class variable**. For example, the `extension_days` attribute is a class variable as it is a property of all students.

All students are able to do homework, attend lecture, and go to office hours. When functions belong to a specific object, they are called **methods**. In this case, these actions would be methods of `Student` objects.

Here is a recap of what we discussed above:

- **class**: a template for creating objects
- **instance**: a single object created from a class
- **instance variable**: a data attribute of an object, specific to an instance
- **class variable**: a data attribute of an object, shared by all instances of a class
- **method**: a bound function that may be called on all instances of a class

Instance variables, class variables, and methods are all considered **attributes** of an object.

Q3: WWPD: Student OOP

Below we have defined the classes `Professor` and `Student`, implementing some of what was described above. Remember that Python passes the `self` argument implicitly to methods when calling the method directly on an object.

```
class Student:

    extension_days = 3 # this is a class variable

    def __init__(self, name, staff):
        self.name = name # this is an instance variable
        self.understanding = 0
        staff.add_student(self)
        print("Added", self.name)

    def visit_office_hours(self, staff):
        staff.assist(self)
        print("Thanks, " + staff.name)

class Professor:

    def __init__(self, name):
        self.name = name
        self.students = {}

    def add_student(self, student):
        self.students[student.name] = student

    def assist(self, student):
        student.understanding += 1

    def grant_more_extension_days(self, student, days):
        student.extension_days = days
```

What will the following lines output?

```
>>> callahan = Professor("Callahan")
>>> elle = Student("Elle", callahan)
```

Added Elle

```
>>> elle.visit_office_hours(callahan)
```

Thanks, Callahan

```
>>> elle.visit_office_hours(Professor("Paulette"))
```

Thanks, Paulette

```
>>> elle.understanding
```

2

```
>>> [name for name in callahan.students]
```

['Elle']

```
>>> x = Student("Vivian", Professor("Stromwell")).name
```

Added Vivian

```
>>> x
```

'Vivian'

```
>>> [name for name in callahan.students]
```

['Elle']

```
>>> elle.extension_days
```

3

```
>>> callahan.grant_more_extension_days(elle, 7)
>>> elle.extension_days
```

7

```
>>> Student.extension_days
```

3

Q4: Keyboard

We'd like to create a `Keyboard` class that takes in an arbitrary number of `Button`s and stores these `Button`s in a dictionary. The keys in the dictionary will be `int`s that represent the position on the `Keyboard`, and the values will be the respective

`Button`. Fill out the methods in the `Keyboard` class according to each description, using the doctests as a reference for the behavior of a `Keyboard`.

Hint: You can iterate over *args as if it were a list.

```
class Button:
    def __init__(self, pos, key):
        self.pos = pos
        self.key = key
        self.times_pressed = 0

class Keyboard:
    """A Keyboard takes in an arbitrary amount of buttons, and has a
    dictionary of positions as keys, and values as Buttons.
    >>> b1 = Button(0, "H")
    >>> b2 = Button(1, "I")
    >>> k = Keyboard(b1, b2)
    >>> k.buttons[0].key
    'H'
    >>> k.press(1)
    'I'
    >>> k.press(2) # No button at this position
    ''
    >>> k.typing([0, 1])
    'HI'
    >>> k.typing([1, 0])
    'IH'
    >>> b1.times_pressed
    2
    >>> b2.times_pressed
    3
    """
    def __init__(self, *args):
        self.buttons = {}
        for button in args:
            self.buttons[button.pos] = button

    def press(self, info):
        """Takes in a position of the button pressed, and
        returns that button's output."""
        if info in self.buttons.keys():
            b = self.buttons[info]
            b.times_pressed += 1
            return b.key
        return ''

    def typing(self, typing_input):
        """Takes in a list of positions of buttons pressed, and
        returns the total output."""
        accumulate = ''
        for pos in typing_input:
            accumulate+=self.press(pos)
        return accumulate
```