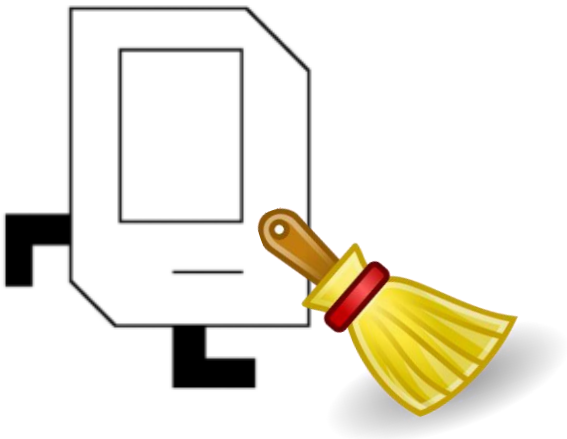
Classes + Objects

CS106A, Stanford University

Housekeeping



- Hope you're well!
- The Stanford Honor Code
  - CS106A retraction policy
    - Wrote my own code, got help from LaIR/staff → good
    - Looked up how a particular function worked online → good
    - Talked with my friends about strategies/approaches → good
    - Copied solution code from another source/person → bad
    - Friend and I collaborated on one solution and both turned it in → bad
  - Be honest with yourself about what happened
  - Deadline to retract any assignments: May 27th

Review: Sorting

Basic Sorting

- The **`sorted`** function orders elements in a collection in increasing (non-decreasing) order
  - Can sort any type that support < and == operations
  - For example: int, float, string
  - **`sorted`** returns new collection (original collection unchanged)

```
>>> nums = [8, 42, 4, 8, 15, 16]
>>> sorted_list = sorted(nums)
>>> sorted_list
[4, 8, 8, 15, 16, 42]
```

Intermediate Sorting

- Can sort elements in decreasing (non-increasing) order
  - Use the optional parameter **`reverse=True`**

```
>>> nums = [8, 42, 4, 8, 15, 16]
>>> sorted(nums, reverse=True)
[42, 16, 15, 8, 8, 4]

>>> strs = ['banana', 'CHERRY', 'apple', 'donut']
>>> sorted(strs, reverse=True)
['donut', 'banana', 'apple', 'CHERRY']
```

- Note case sensitivity of sorting strings!
  - <u>Any</u> uppercase letter is less than <u>any</u> lowercase letter
  - For example: **`'Z'`** < **`'a'`**

Advanced Sorting

- Sorting using a custom function
  - Use the optional parameter **`key=`**<***function name***>
  - Elements sorted based on value returned from **`key`** function

```
def get_len(s):
    return len(s)

def main():
    strs = ['a', 'bbbb', 'cc', 'zzz']
    sorted_strs = sorted(strs, key=get_len)
    print(sorted_strs)
```

Output:

```
['a', 'cc', 'zzz', 'bbbb']
```

Super Deluxe Advanced Sorting

- Sorting a list of tuples with a custom function
  - Use the optional parameter **`key=`**<*function name*>

```
def get_count(food):
    return food[1]

def main():
    foods = [('apple', 5), ('banana', 2), ('chocolate', 137)]
    sort_names = sorted(foods)
    print(sort_names)
    sort_count = sorted(foods, key=get_count)
    print(sort_count)
    rev_sort_count = sorted(foods, key=get_count, reverse=True)
    print(rev_sort_count)
```

Output:

```
[('apple', 5), ('banana', 2), ('chocolate', 137)]
[('banana', 2), ('apple', 5), ('chocolate', 137)]
[('chocolate', 137), ('apple', 5), ('banana', 2)]
```

Yes, that's in sorted order!

Learning Goals

1. Learning about Object-Oriented Programming
2. Writing code using Classes and Objects in Python

Object-Oriented Programming
(OOP)
It's not a mistake!

Object-Oriented Programming

- There are different *paradigms* in programming
- So far, you've learned *imperative* programming
  - Provide series of direct commands for program execution
  - Commands are changing the program's *state*
- *Object-oriented* programming
  - Define *objects* that contain data and behavior (functions)
  - Program is (mostly) an interaction between objects
  - You are calling functions of objects (called "methods")
- Python allows for programming in either paradigm!
  - Other programming paradigms exist, but we won't talk about those in this class

What are Classes and Objects?

- Classes are like blueprints
  - They provide a template for a kind of object
  - They define a new **type**
  - E.g., "Human" would be a class
    - Generally, have two arms, have two legs, breathe air, etc.

- Objects are *instances* of Classes
  - Can have multiple objects of the same Class type
  - E.g., <u>You</u> would be an instance of the Human class
    - So, you have the properties of your Class (Human)
  - There are lots of other people out there too
    - You are all of type "Human"
    - You are all objects of the same Class

Example of a Class in Python

- Let's create a Counter class
  - Can ask is for the "next" ticket number
  - Need to keep track of next ticket number
  - Class names start with <u>Uppercase</u> character
  - No **`main()`** function (Class is **not** a program)

```
class Counter:

    # Constructor
    def __init__(self):
        self.ticket_num = 0    # "instance" variable

    # Method (function) that returns next ticket value
    def next_value(self):
        self.ticket_num += 1
        return self.ticket_num
```

Two (or double) underscores – called "dunder" for short

Let's See It In Action:
counter.py

Objects are Mutable

- When you pass an object as a parameter, changes to object in that function persist after function ends

```
from counter import Counter     # import the Class

def count_two_times(count):
    for i in range(2):
        print(count.next_value())

def main():
    count1 = Counter()
    count2 = Counter()

    print('Count1: ')
    count_two_times(count1)

    print('Count2: ')
    count_two_times(count2)

    print('Count1: ')
    count_two_times(count1)
```

Output:

```
Count1:
1
2
Count2:
1
2
Count1:
3
4
```

General Form for Writing a Class

- Filename for class is usually ***classname*.py**
  - Filename is usually lowercase version of class name in file

```
class Classname:

    # Constructor
    def __init__(self, additional parameters):
        body
        self.variable_name = value    # example instance variable

    # Method
    def method_name(self, additional parameters):
        body
```

Constructor of a Class

- Constructor
  - Syntax:

    def __init__(self, *additional parameters*):
    ** *body***

- Called when a new object is being created
  - Does not explicitly specify a return value
  - New object is created and returned
    - Can think of constructor as the "factory" that creates new objects
  - Responsible for initializing object (setting initial values)
  - Generally, where instance variables are created (with **self**)

    self.*variable_name* = *value* # create instance variable

Instance Variables

- Instance variables are variable associated with objects
  - Each object get its **<u>own set</u>** of instance variables
  - Generally, they are initialized in constructor for class
  - Instance variables accessed using **`self`**:

    `self.`***<u>variable_name</u>*** `=` ***<u>value</u>***
  - Self really refers to the object that a method is called on

```
def main():
    count1 = Counter()
    count2 = Counter()
    x = count1.next_value()
    y = count2.next_value()
```

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```
def __init__(self):
    self.ticket_num = 0
```

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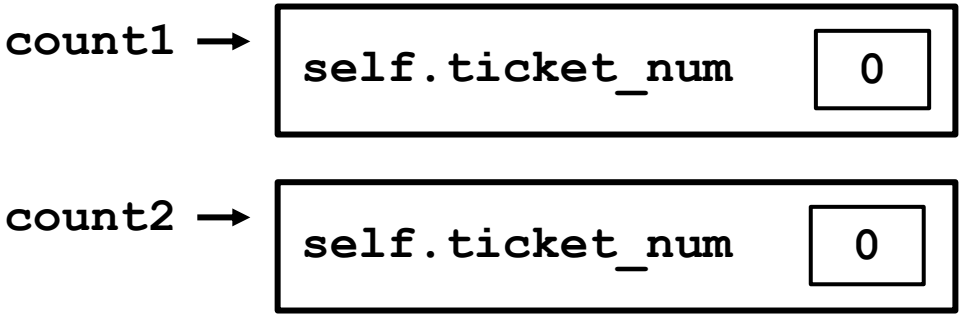

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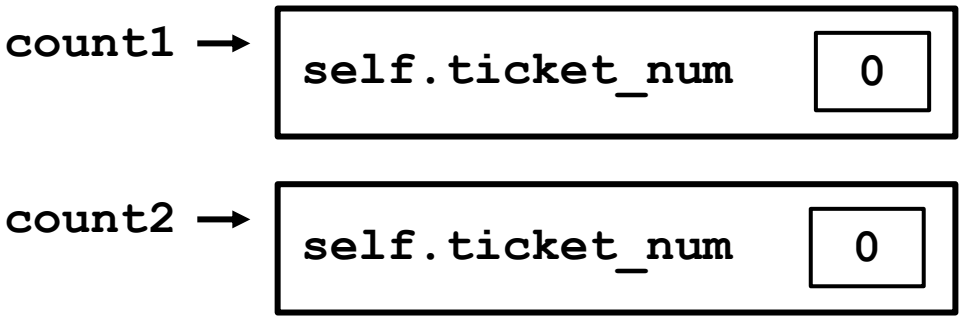

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    count1 = Counter()
    count2 = Counter()
    x = count1.next_value()
    y = count2.next_value()
```

count1

```
def next_value(self):
    self.ticket_num += 1
    return self.ticket_num
```

count1 → `self.ticket_num` [0]

count2 → `self.ticket_num` [0]

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    count1 = Counter()
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    x = count1.next_value()
    y = count2.next_value()
```

count1

```
def next_value(self):
    self.ticket_num += 1
    return self.ticket_num
```

count1 → `self.ticket_num` [1]

count2 → `self.ticket_num` [0]

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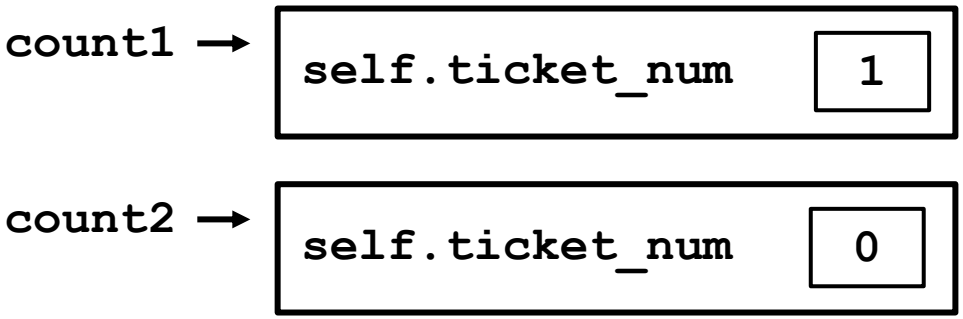

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    count1 = Counter()
    count2 = Counter()
    x = count1.next_value()
    y = count2.next_value()
```

count2

```
def next_value(self):
    self.ticket_num += 1
    return self.ticket_num
```

count1 → `self.ticket_num` [1]

count2 → `self.ticket_num` [0]

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    y = count2.next_value()
```

count2

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count1 → `self.ticket_num` [1]

count2 → `self.ticket_num` [1]

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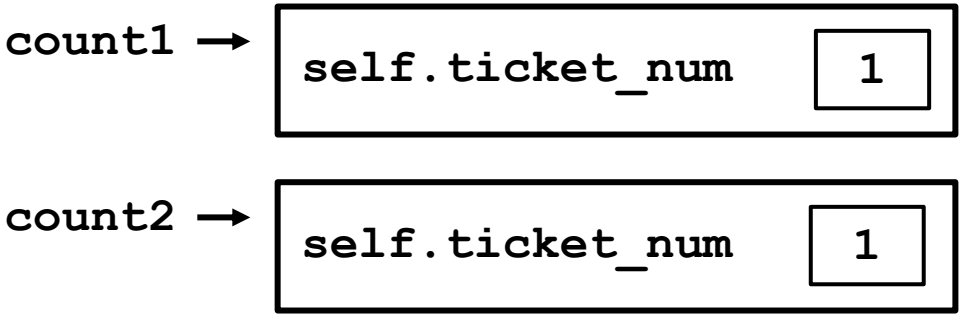

Methods (Functions) in Class

- Methods (name used for functions in objects)
  - Syntax:

    `def` ***method_name*** **`(self,`** ***additional parameters*** **`):`**
    body

- Works like a regular function in Python
  - Can return values (like a regular function)
  - Has access to *instance* variables (through **`self`**):

    `self.`***variable_name*** **`=`** ***value***
  - Called using an object:

    object_name **.** ***method_name*** **(*****additional parameters*****)**
  - Recall, parameter **`self`** is automatically set by Python as the object that this method is being called on
    - You write: **`number = count1.next_value()`**
    - Python treats it as: **`number = next_value(count1)`**

Another Example: Students

- Want a Class to keep track information for Students
  - Each student has information:
    - Name
    - ID number
    - Units completed
  - Want to specify a name and ID number when creating a student object
    - Initially, units completed set to 0
  - Student's number of units completed can be updated over time
  - Also want to be able to check if a student can graduate
    - Student needs to have at least `UNITS_TO_GRADUATE` units

Bring Me the Students!

student.py

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