Week 3 - Classes (not the school kind)

Inspired by class notes from BYU's ACME Program: Link

What can I do with this?

Make a list of things that you can do with each individual item below:

- A Table
- A laptop computer
- An Apple

What are classes

- A critical element of object-oriented programming
- Directions for creating objects
  - A list of "recipes" for utilizing that object
- Allow us to generate multiple related objects, and to manipulate them, quickly and efficiently

Classes

Let's imagine we work at a cafeteria, and that we want to represent a sandwich as code. There are certain things we would want to know about every sandwich:

1. Whose is it?
2. What toppings will we put on our sandwich?
3. What kind of bread will we use?

How can we start designing our sandwich code?

Creating a new class

```
class Sandwich(object):
        def __init__(self, owner, bread='white'):
                self.owner = owner
                self.bread = bread
                self.toppings = []
```

The FIRST thing we need to do is to initialize an object of class `Sandwich`. We do this by using the `__init__()` method (methods are functions assigned to a class object)

- We tell our object what arguments to expect, and store these values as **attributes** of our object

Creating a New Class

```
>>> mine = Sandwich('Dusty')
>>> print(mine)
<__main__.Sandwich object at 0x7f83ba7cc390>
```

So, I created a delicious sandwich class, but I can't print anything useful about it!

- We have to explain to the interpreter how to implement basic functions using our object
- We can declare basic functionality using *magic methods*

Magic Methods (MANY more here)

Operator	Method
+	object.__add__(self, other)
-	object.__sub__(self, other)
*	object.__mul__(self, other)
//	object.__floordiv__(self, other)
/	object.__truediv__(self, other)
**	object.__pow__(self, other[, modulo])
print()	object.__repr__(self)

Magic Methods

Not all of the magic methods will make sense for all classes. Which standard operations do you think would make sense for our `Sandwich` class?

Magic Methods

Not all of the magic methods will make sense for all classes. Which standard operations do you think would make sense for our `Sandwich` class?

- Adding (we can ADD toppings)
- Subtracting (we can REMOVE toppings)
- Equality (we can determine if two sandwiches are the same)
    - If we define equality, we should also define when two sandwiches are NOT equal.
- A formatted representation for printing

Magic Methods - Adding

```
class Sandwich(object):
  def __init__(self, owner, bread='white'):
    self.owner = owner
    self.bread = bread
    self.toppings = []
  def __add__(self, topping):
    self.toppings.append(topping)
```

Here, we add the magic method for addition to our class, and state that the `+` operator should append the topping that follows it to our list of toppings, then return that updated list.

Magic Methods - Subtracting

```
class Sandwich(object):
  def __init__(self, owner, bread='white'):
    self.owner = owner
    self.bread = bread
    self.toppings = []
  def __add__(self, topping):
    self.toppings.append(topping)
  def __sub__(self, topping):
    if topping in self.toppings:
      self.toppings.remove(topping)
    else:
      print("Topping not present, and can't be removed.")
```

Subtracting is trickier, but we need to declare that the `-` operator should check for a topping in our list, and remove it **if present**.

Magic Methods - (In)Equality

```
class Sandwich(object):
  def __init__(self, owner, bread='white'):
    self.owner = owner
    self.bread = bread
    self.toppings = []
  ...  # This is where the add and sub methods are
  def __eq__(self, other):
    if (self.bread==other.bread) and
      (sorted(self.toppings) == sorted(other.toppings)):
      return True
    else:
      return False
  def __ne__(self, other):
    return not (self == other)
```

Note that we have to define both `=` and `!=`

Magic Methods - Representations

```
class Sandwich(object):
  def __init__(self, owner, bread='white'):
    self.owner = owner
    self.bread = bread
    self.toppings = []
  ...  # Other magic methods here
  def __repr__(self):
    alltops = "Toppings:\t"
    for i in self.toppings:
      alltops += " %s" % i
    return "Owner:\t\t "+ str(self.owner) +"\n" +
      alltops + "\nBread:\t\t " + self.bread
```

Now we can print our sandwich!

Methods - Try It!

We can also create methods that are based on the unique functionality of our class of objects. Since we are [pretending to be] working at a store, we might care about pricing a sandwich.

- Let's call the method `get_price`, and have it take two arguments (`self` and a `discount`) with `discount` having a default value of `0`, and store `price` as an attribute of our sandwich object
- Each topping costs $1
- Specialty bread (not "white" bread) is $2, white bread is provided at no cost

Methods

Possible Answer:

```
class Sandwich(object):
  def __init__(self, owner, bread='white'):
    self.owner = owner
    self.bread = bread
    self.toppings = []
  ...  # Magic methods go here
  def get_price(self, discount=0.0):
    self.price = 0
    for i in self.toppings:
      self.price += 1
    if self.bread != 'white':
      self.price += 2
    if discount > 0:
      self.price *= (1-discount)
    return self.price
```

Documentation

When we create a class, a function, or a method, we should be sure to **document** that object!

- We can then remember how to use it after long breaks
- Other people can make use of our code without having to decipher each line

We can document by modifying the *docstring* of an object.

Documenting

```
class Sandwich(object):
  """A class defining a sandwich. Toppings can be added
  and removed, and the owner and bread type can be
  declared upon initiation.

  Attributes:
    owner (str): the person puchasing the sandwich
    bread (str): the type of bread to be used
    toppings (list): a list of the toppings (str) that
      are to be put on the sandwich
    price (float): the price of the sandwich
  """
  def get_price(self):
  ... # Class continues below
```

Documenting

```
class Sandwich(object):
  ... # Docstring for Sandwich class
  def get_price(self, discount=0.0):
    """A function to calculate the price of the sandwich.
    Each topping costs $1, and bread that is not 'white'
    costs $2. Discounts should be applied as the amount
    to be deducted.

    Inputs:
      discount (float): amount to be discounted from
        total price

    Returns:
      A Sandwich object with a price attribute
    """
    ...
    return self.price
```

Lab Time!

Extra Practice!

Create your own `ComplexNumber` class!

1. Complex numbers have a real and an imaginary part. The `__init__()` method should therefore accept two numbers. Store the first as self.real and the second as self.imag.
2. Implement a `conjugate()` method that returns the object's complex conjugate (as a new `ComplexNumber` object). Recall that $x = a + bi \implies \bar{x} = a - bi$, where $\bar{x}$ is the complex conjugate of x.

More Practice

3. Add the following magic methods to your `ComplexNumber` class:
    - `__abs__()` determines the output of the builtin `abs()` function (absolute value). Implement `__abs__()` so that it returns the magnitude of the complex number. Recall that $|a + bi| = \sqrt{a^2 + b^2}$.
    - Implement `__lt__()` and `__gt__()` so that `ComplexNumber` objects can be compared by their magnitudes. That is, $(a + bi) < (c + di)$ if and only if $|a + bi| < |c + di|$, and so on.

Even More Practice

3. Add the following magic methods to your `ComplexNumber` class:
    - Implement `__eq__()` and `__ne__()` so that two `ComplexNumber` objects are equal if and only if they have the same real and imaginary parts.
    - Implement `__add__()`, `__sub__()`, `__mul__()`, and `__div__()` appropriately. Each of these should return a new `ComplexNumber` object.