Lecture 11 – Classes & Objects continued …

https://cw.fel.cvut.cz/wiki/courses/be5b33prg/start

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RECAP: OOP PERSPECTIVE

OOP is about changing the perspective

- Syntax for a function call: **function_name(variable)**
  function is the one who executes on the variable
- Syntax in OOP: **object_name.function_name()**
  object is the one who executes its method on given data / attribute

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_I.html

RECAP: CLASS vs. TUPLE

```python
class Point:
    """ Create a new Point, at coordinates x, y """

    def __init__(self, x=0, y=0):
        """ Create a new point at x, y """
        self.x = x
        self.y = y

    def distance_from_origin(self):
        """ Compute my distance from the origin """
        return ((self.x ** 2) + (self.y ** 2)) ** 0.5
```

- Advantage of using a class (*e.g. Point*) rather than a tuple is that **class methods are sensible operations** for points, but may not be appropriate for other tuples (*e.g. calculate the distance from the origin*)
- Class allows to **group together sensible operations** as well as data to apply the methods on
- Each instance of the class has its **own state**
- Method **behaves like a function** but it is invoked on a specific instance

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_I.html

RECAP: EXAMPLE – INSTANCE METHODS

```
class Inst:

    def __init__(self, name):
        self.name = name

    def introduce(self):
        print("Hello, I am %s, and my name is " %(self, self.name))
```

```
myinst = Inst("Test Instance")
otherinst = Inst("An other instance")
myinst.introduce()
# outputs: Hello, I am <Inst object at x>, and my name is Test Instance
otherinst.introduce()
# outputs: Hello, I am <Inst object at y>, and my name is An other instance
```

SOURCE https://stackoverflow.com/questions/17134653/difference-between-class-and-instance-methods

RECAP: EXAMPLE – CLASS METHODS

```
class Cls:

    @classmethod
    def introduce(cls):
        print("Hello, I am %s!" %cls)
```

```
Cls.introduce() # same as Cls.introduce(Cls)
# outputs: Hello, I am <class 'Cls'>
```

Notice that again `Cls` is passed hiddenly, so we could also say `Cls.introduce(Inst)` and get output `"Hello, I am <class 'Inst'>`. This is particularly useful when we're inheriting a class from `Cls`:

```
class SubCls(Cls):
    pass

SubCls.introduce()
# outputs: Hello, I am <class 'SubCls'>
```

SOURCE https://stackoverflow.com/questions/17134653/difference-between-class-and-instance-methods

RECAP: OBJECT PROPERTIES

- `__init__`: the initialisation method of an object, which is called when the object is created.
- `__str__`: the string representation method of an object, which is called when you use the `str` function to convert that object to a string.
- `__class__`: an attribute which stores the the class (or type) of an object – this is what is returned when you use the `type` function on the object.
- `__eq__`: a method which determines whether this object is equal to another. There are also other methods for determining if it's not equal, less than, etc.. These methods are used in object comparisons, for example when we use the equality operator `==` to check if two objects are equal.
- `__add__` is a method which allows this object to be added to another object. There are equivalent methods for all the other arithmetic operators. Not all objects support all arithemtic operations – numbers have all of these methods defined, but other objects may only have a subset.
- `__iter__`: a method which returns an iterator over the object – we will find it on strings, lists and other iterables. It is executed when we use the `iter` function on the object.
- `__len__`: a method which calculates the length of an object – we will find it on sequences. It is executed when we use the `len` function of an object.
- `__dict__`: a dictionary which contains all the instance attributes of an object, with their names as keys. It can be useful if we want to iterate over all the attributes of an object. `__dict__` does not include any methods, class attributes or special default attributes like `__class__`.

SOURCE http://python-textbok.readthedocs.io/en/1.0/Classes.html# UNDER CC BY-SA 4.0 licence Revision 8e685e710775

RECAP: OBJECT PROPERTIES

```python
class Person:
    def __init__(self, name, surname):
        self.name = name
        self.surname = surname

    def __eq__(self, other):  # does self == other?
        return self.name == other.name and self.surname == other.surname

    def __gt__(self, other):  # is self > other?
        if self.surname == other.surname:
            return self.name > other.name
        return self.surname > other.surname

    # now we can define all the other methods in terms of the first two

    def __ne__(self, other):  # does self != other?
        return not self == other  # this calls self.__eq__(other)

    def __le__(self, other):  # is self <= other?
        return not self > other  # this calls self.__gt__(other)

    def __lt__(self, other):  # is self < other?
        return not (self > other or self == other)

    def __ge__(self, other):  # is self >= other?
        return not self < other
```

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RECAP: INSPECTING OBJECTS

```
In[2]: class Person:
   ...:     def __init__(self, name, surname):
   ...:         self.name = name
   ...:         self.surname = surname
   ...:
   ...:     def fullname(self):
   ...:         return "%s %s" % (self.name, self.surname)
   ...:
   ...: jane = Person("Jane", "Smith")
   ...:
In[3]: print(dir(jane))
['__doc__', '__init__', '__module__', 'fullname', 'name', 'surname']

In[4]:
```

- Use function **dir** for inspecting objects: output list of the attributes and methods

EXAMPLES FROM http://python-textbok.readthedocs.io/en/1.0/Classes.html# UNDER CC BY-SA 4.0 licence Revision 8e685e710775

```
1   class Rectangle:
2       """ A class to manufacture rectangle objects """
3
4       def __init__(self, posn, w, h):
5           """ Initialize rectangle at posn, with width w, height h """
6           self.corner = posn
7           self.width = w
8           self.height = h
9
10      def __str__(self):
11          return  "({0}, {1}, {2})"
12                      .format(self.corner, self.width, self.height)
13
```

- **EXAMPLE**: assume a **rectangle** that is oriented either vertically or horizontally, never at an angle;
  specify the **upper-left corner** of the rectangle, and its **size**

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

CLASSES, OBJECTS

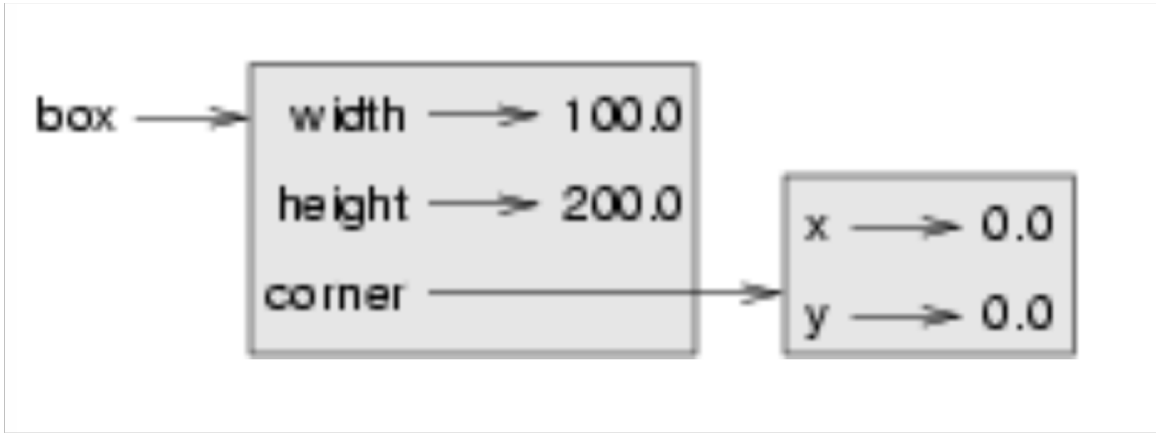
```
1   class Rectangle:
2       """ A class to manufacture rectangle objects """
3
4       def __init__(self, posn, w, h):
5           """ Initialize rectangle at posn, with width w, height h """
6           self.corner = posn
7           self.width = w
8           self.height = h
9
10      def __str__(self):
11          return  "({0}, {1}, {2})"
12                      .format(self.corner, self.width, self.height)
13
14  box = Rectangle(Point(0, 0), 100, 200)
15  bomb = Rectangle(Point(100, 80), 5, 10)     # In my video game
16  print("box: ", box)
17  print("bomb: ", bomb)
```

```
box: ((0, 0), 100, 200)
bomb: ((100, 80), 5, 10)
```

- To specify the upper-left corner embed a **Point object** within the new **Rectangle object**
- Create two new Rectangle objects, and then print them producing

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

DOT OPERATOR COMPOSITION



- The dot operator composes.
- The expression **box.corner.x** means:

"Go to the object that box refers to and select its attribute named corner, then go to that object and select its attribute named x"

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

OBJECTS ARE MUTABLE


```
1  class Rectangle:
2      # ...
3
4      def grow(self, delta_width, delta_height):
5          """ Grow (or shrink) this object by the deltas """
6          self.width += delta_width
7          self.height += delta_height
8
9      def move(self, dx, dy):
10         """ Move this object by the deltas
11         self.corner.x += dx
12         self.corner.y += dy
```

```
>>> r = Rectangle(Point(10,5), 100, 50)
>>> print(r)
((10, 5), 100, 50)
>>> r.grow(25, -10)
>>> print(r)
((10, 5), 125, 40)
>>> r.move(-10, 10)
print(r)
((0, 15), 125, 40)
```

- Change the state of an object by making an assignment to one of its attributes

```
box.width += 50
box.height += 100
```

- Provide a method to encapsulate this inside the class
- Provide another method to *move the position of the rectangle elsewhere*

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

OBJECT EQUALITY

```
>>> p1 = Point(3, 4)
>>> p2 = Point(3, 4)
>>> p1 is p2
False
```

```
>>> p3 = p1
>>> p1 is p3
True
```

- **EXAMPLE**: If two *objects* are the same, does it mean they contain the **same data** or that they are the **same object**?
- The **is** operator was used in previous examples on the lists when explaining aliases: *it allows to find out if two references refer to the same object*

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

- **Shallow copy**: is defined as constructing a new collection object and then populating it with references to the child objects found in the original, i.e. a shallow copy is only one level deep. The copying process does not recurse and therefore will not create copies of the child objects.

- **Deep copy**: is defined as recursive copying process, i.e. first constructing a new collection object and then recursively populating it with copies of the child objects found in the original. *Copying an object this way walks the whole object tree to create a fully independent clone of the original object and all of its children*.

source https://realpython.com/copying-python-objects/

OBJECT EQUALITY

```
1  def same_coordinates(p1, p2):
2      return (p1.x == p2.x) and (p1.y == p2.y)
```

```
>>> p1 = Point(3, 4)
>>> p2 = Point(3, 4)
>>> same_coordinates(p1, p2)
True
```

- **Shallow equality**: When **is** is **True**, this type of equality is *shallow equality* because it compares only the **references** and not the *contents* of the objects
- **Deep equality**: To compare the **contents** of the objects a function like *same_coordinates* needs to be created
- **IMPORTANT**: **If two variables refer to the same object, they have both shallow and deep equality**

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

OBJECT EQUALITY

```
1  p = Point(4, 2)
2  s = Point(4, 2)
3  print("== on Points returns", p == s)
4  # By default, == on Point objects does a shallow equality test
5
6  a = [2,3]
7  b = [2,3]
8  print("== on lists returns",  a == b)
9  # But by default, == does a deep equality test on lists
```

```
== on Points returns False
== on lists returns True
```

- Think about shallow & deep copy when designing classes!
- **EXAMPLE**: even though the two lists (or tuples, etc.) are *distinct objects with different memory addresses*, for lists the == operator tests for *deep equality*, while in the case of objects (points) it makes a *shallow test*

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

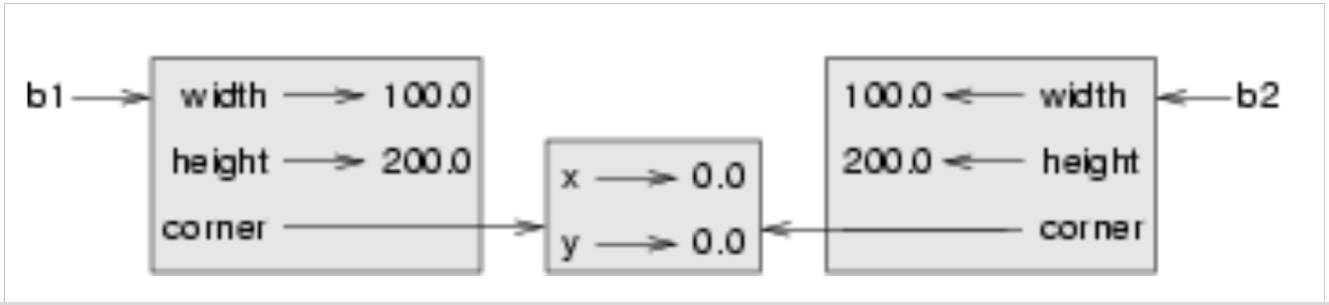
OBJECT COPY

```
>>> import copy
>>> p1 = Point(3, 4)
>>> p2 = copy.copy(p1)
>>> p1 is p2
False
>>> same_coordinates(p1, p2)
True
```

- Aliasing makes code difficult to read – *changes made in one place might have unexpected effects in another place*
- Copying object is an **alternative to aliasing:** the **copy module** contains a function copy that can duplicate any object
- **EXAMPLE**: import the copy module and use the copy function to make a new Point: p1 and p2 are *not the same point*, but they *contain the same data* (shallow copy)

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

OBJECT COPY



- **EXAMPLE**: Assume Rectangle, which contains a reference to a Point: copy copies the reference to the Point object, so both the old Rectangle and the new one refer to the same Point
- **invoking** *grow* on one of the Rectangle objects would not affect the other,
- **invoking** *move* on either would affect both
- **The shallow copy has created an alias to the Point that represents the corner**
- Copy module contains a function named **deepcopy** that copies not only the object but also any embedded objects

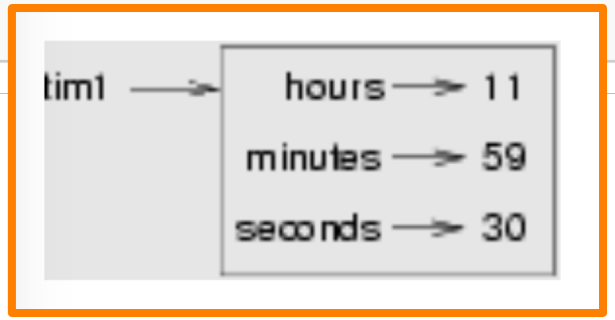
source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

- **Deep copy**: To copy the contents of an object as well as any embedded objects, and any objects embedded in them, etc. (*implemented as deepcopy function in copy module*)
- **Deep equality**: Equality of values, or two references that point to objects that have the same value
- **Shallow copy**: To copy the contents of an object, including any references to embedded objects (one level copy). (*implemented by the copy function in the copy module*)
- **Shallow equality**: Equality of references, or two references that point to the same object

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

```
1  class MyTime:
2
3      def __init__(self, hrs=0, mins=0, secs=0):
4          """ Create a MyTime object initialized to hrs, mins, secs """
5          self.hours = hrs
6          self.minutes = mins
7          self.seconds = secs
```

```
1  tim1 = MyTime(11, 59, 30)
```



- **EXAMPLE**: user-defined type called **MyTime** that records the time of day
- Initializer using an **__init__** method to ensure that every instance is created with appropriate attributes

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

PURE FUNCTIONS

```
1  def add_time(t1, t2):
2      h = t1.hours + t2.hours
3      m = t1.minutes + t2.minutes
4      s = t1.seconds + t2.seconds
5      sum_t = MyTime(h, m, s)
6      return sum_t
```

```
>>> current_time = MyTime(9, 14, 30)
>>> bread_time = MyTime(3, 35, 0)
>>> done_time = add_time(current_time, bread_time)
>>> print(done_time)
12:49:30
```

EXAMPLE: create two **MyTime** objects:

- **current_time**, which contains the current time
- **bread_time**, which contains the amount of time it takes for a breadmaker to make bread
- use **add_time** to figure out when the bread will be done

PROBLEM: we do not deal with cases where *the number of seconds or minutes adds up to more than sixty*.

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

PURE FUNCTIONS

```
1  def add_time(t1, t2):
2      h = t1.hours + t2.hours
3      m = t1.minutes + t2.minutes
4      s = t1.seconds + t2.seconds
5      sum_t = MyTime(h, m, s)
6      return sum_t
```

```
>>> current_time = MyTime(9, 14, 30)
>>> bread_time = MyTime(3, 35, 0)
>>> done_time = add_time(current_time, bread_time)
>>> print(done_time)
12:49:30
```

- **EXAMPLE**: Two versions of a function **add_time**, *pure* & *modifier*, which calculates the sum of two MyTime objects

- Function that creates a new MyTime object and returns a reference to the new object is **pure function** because it does not modify any of the objects passed to it as parameters and it has no side effects

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1   def add_time(t1, t2):
2
3       h = t1.hours + t2.hours
4       m = t1.minutes + t2.minutes
5       s = t1.seconds + t2.seconds
6
7       if s >= 60:
8           s -= 60
9           m += 1
10
11      if m >= 60:
12          m -= 60
13          h += 1
14
15      sum_t = MyTime(h, m, s)
16      return sum_t
```

PROBLEM: Do we now deal with cases where the number of seconds or minutes adds up to more than sixty?

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  def increment(t, secs):
2      t.seconds += secs
3
4      if t.seconds >= 60:
5          t.seconds -= 60
6          t.minutes += 1
7
8      if t.minutes >= 60:
9          t.minutes -= 60
10         t.hours += 1
```

```
1  def increment(t, seconds):
2      t.seconds += seconds
3
4      while t.seconds >= 60:
5          t.seconds -= 60
6          t.minutes += 1
7
8      while t.minutes >= 60:
9          t.minutes -= 60
10         t.hours += 1
```

- It can be useful for a function to **modify** one or more of the objects it gets as parameters
- Usually, the **caller keeps a reference** to the objects it passes, so any changes the function makes are visible to the caller (*modifier function*)
- Increment, which adds a given number of seconds to a MyTime object, is a natural example of a **modifier**

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

MODIFIERS

```python
class MyTime:
    # Previous method definitions here...

    def increment(self, seconds):
        self.seconds += seconds

        while self.seconds >= 60:
            self.seconds -= 60
            self.minutes += 1

        while self.minutes >= 60:
            self.minutes -= 60
            self.hours += 1
```

```python
current_time.increment(500)
```

- **SOLUTION**: Include functions that work with MyTime objects into the MyTime class (conversion of increment to a method)
- Move the definition into the class definition and change the name of the first parameter to self (Python convention!)

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

INSIGHT

```
1  class MyTime:
2      # ...
3
4      def to_seconds(self):
5          """ Return the number of seconds represented
6              by this instance
7          """
8          return self.hours * 3600 + self.minutes * 60 + self.seconds
```

```
1  hrs = tsecs // 3600
2  leftoversecs = tsecs % 3600
3  mins = leftoversecs // 60
4  secs = leftoversecs % 60
```

- **INSIGHT**: MyTime object is a **three-digit number in base 60**!
- Another approach —convert the MyTime object into a *single number*
- The above method is added to the MyTime class to convert any instance into a corresponding number of seconds

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1   class MyTime:
2       # ...
3
4       def __init__(self, hrs=0, mins=0, secs=0):
5           """ Create a new MyTime object initialized to hrs, mins, secs.
6               The values of mins and secs may be outside the range 0-59,
7               but the resulting MyTime object will be normalized.
8           """
9
10          # Calculate total seconds to represent
11          totalsecs = hrs*3600 + mins*60 + secs
12          self.hours = totalsecs // 3600        # Split in h, m, s
13          leftoversecs = totalsecs % 3600
14          self.minutes = leftoversecs // 60
15          self.seconds = leftoversecs % 60
```

- In OOP **wrap together the data and the operations**
- Solution is to *rewrite the class initializer* so that it can cope with initial values of seconds or minutes that are outside the normalized values

(*normalized time: 3 hours 12 minutes and 20 seconds; the same time but not normalized 2 hours 70 minutes and 140 seconds*)

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

EXAMPLE

```
>>> t1 = MyTime(10, 55, 12)
>>> t2 = MyTime(10, 48, 22)
>>> after(t1, t2)                # Is t1 after t2?
True
```

- **EXAMPLE**: The **after** function should compare two times and *specify whether the first time is strictly after the second*
- More complicated because it operates on **two MyTime objects** not just one

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

EXAMPLE

```
1  class MyTime:
2      # Previous method definitions here...
3
4      def after(self, time2):
5          """ Return True if I am strictly greater than time2 """
6          if self.hours > time2.hours:
7              return True
8          if self.hours < time2.hours:
9              return False
10
11         if self.minutes > time2.minutes:
12             return True
13         if self.minutes < time2.minutes:
14             return False
15         if self.seconds > time2.seconds:
16             return True
17
18         return False
```

```
1  if current_time.after(done_time):
2      print("The bread will be done before it starts!")
```

- **Lines 11-18** will only be reached if the two hour fields are the same.
- The test at **line 16** is only executed if both times have the same hours and the same minutes.

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  class MyTime:
2      # Previous method definitions here...
3
4      def after(self, time2):
5          """ Return True if I am strictly greater than time2 """
6          return self.to_seconds() > time2.to_seconds()
```

- The whole example can be made easier using the previously discovered insight of converting the time into single integer!
- **This is a great way to code this**:

  If we want to tell if the first time is after the second time, turn them both into integers and compare the integers.

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```python
class MyTime:
    # Previously defined methods here...

    def __add__(self, other):
        return MyTime(0, 0, self.to_seconds() + other.to_seconds())
```

- **Operator overloading**: *possibility to have different meanings for the same operator when applied to different types*
- **EXAMPLE**: the + in Python means quite different things for integers (**addition**) and for strings (**concatenation**)!
- To override the addition operator + provide a method named **__add__**

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

OPERATOR OVERLOADING

```
1  class MyTime:
2      # Previously defined methods here...
3
4      def __add__(self, other):
5          return MyTime(0, 0, self.to_seconds() + other.to_seconds())
```

```
>>> t1 = MyTime(1, 15, 42)
>>> t2 = MyTime(3, 50, 30)
>>> t3 = t1 + t2
>>> print(t3)
05:06:12
```

- **First parameter** is the object on which the method is invoked
- **Second parameter** is named other to distinguish it from self
- To add two MyTime objects create and return a new MyTime object that contains their sum

- The expression **t1 + t2** is equivalent to **t1.__add__(t2)**

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  class Point:
2      # Previously defined methods here...
3
4      def __add__(self, other):
5          return Point(self.x + other.x,  self.y + other.y)
```

- **EXAMPLE**: back to the Point class – adding two points adds their respective (x, y) coordinates
- **EXAMPLE**: several ways to override the behavior of the multiplication operator by defining a method named **__mul__** or **__rmul__** or both

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

OPERATOR OVERLOADING

```
1  def __mul__(self, other):
2      return self.x * other.x + self.y * other.y
```

```
1  def __rmul__(self, other):
2      return Point(other * self.x,  other * self.y)
```

- If the **left** operand of * is a **Point**, Python invokes **__mul__**, which assumes that the other operand is also a Point (this computes the dot product of the two Points)
- If the left operand of * is a **primitive type** and the right operand is a **Point**, Python invokes **__rmul__**, which performs *scalar multiplication*
- The result is always a *new Point* whose coordinates are a multiple of the original coordinates

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
>>> p1 = Point(3, 4)
>>> p2 = Point(5, 7)
>>> print(p1 * p2)
43
>>> print(2 * p2)
(10, 14)
```

PROBLEM: How is **p2 * 2** evaluated?

```
>>> print(p2 * 2)
AttributeError: 'int' object has no attribute 'x'
```

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

OPERATOR OVERLOADING

```
>>> p1 = Point(3, 4)
>>> p2 = Point(5, 7)
>>> print(p1 * p2)
43
>>> print(2 * p2)
(10, 14)
```

```
>>> print(p2 * 2)
AttributeError: 'int' object has no attribute 'x'
```

- **PROBLEM**: How is **p2 * 2** evaluated?

- Since the first parameter is a Point, Python invokes **__mul__** with 2 as the second argument
- Inside **__mul__**, the program tries to access the **x** coordinate of other, which fails because an integer has no attributes

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  def front_and_back(front):
2      import copy
3      back = copy.copy(front)
4      back.reverse()
5      print(str(front) + str(back))
```

```
>>> my_list = [1, 2, 3, 4]
>>> front_and_back(my_list)
[1, 2, 3, 4][4, 3, 2, 1]
```

- **EXAMPLE**: **front_and_back** – consider a function which prints a list twice, forward and backward
- The reverse method is a **modifier** therefore a copy needs to be made before applying it (this way we prevent to modify the list the function gets as a parameter!)
- Function that can take arguments with different types and handles them accordingly is called **polymorphic**

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  def multadd (x, y, z):
2      return x * y + z
```

```
>>> multadd (3, 2, 1)
7
```

```
>>> p1 = Point(3, 4)
>>> p2 = Point(5, 7)
>>> print(multadd (2, p1, p2))
(11, 15)
>>> print(multadd (p1, p2, 1))
44
```

- **Polymorphism ==** ability to process objects differently based on data type
- There are certain operations that can be applied to many types, such as the arithmetic operations …
- **EXAMPLE**: **multadd** operation takes three parameters: multiplies the first two and then adds the third
- **The first case**: the Point is multiplied by a scalar and then added to another Point.
- **The second case:** the dot product yields a numeric value, so the third parameter also has to be a numeric value

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  def reverse(self):
2      (self.x , self.y) = (self.y, self.x)
```

```
>>> p = Point(3, 4)
>>> front_and_back(p)
(3, 4)(4, 3)
```

- **Python's fundamental rule of polymorphism** is called the **duck typing rule**: *If all of the operations inside the function can be applied to the type, the function can be applied to the type*.

- Operations in the **front_and_back** : *copy, reverse, print*

- **EXAMPLE**: What about our Point class?
  The copy method works on any object; already written a __str__ method for Point objects for the str() conversion, only the reverse method for the Point class is needed!

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```python
import datetime  # we will use this for date objects


class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

    def age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month,
                                 self.birthdate.day):
            age -= 1

        return age


person = Person(
    "Jane",
    "Doe",
    datetime.date(1992, 3, 12),  # year, month, day
    "No. 12 Short Street, Greenville",
    "555 456 0987",
    "jane.doe@example.com"
)
```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```
In[3]: print(person.name)
Jane
In[4]: print(person.email)
jane.doe@example.com
In[5]: print(person.age())
25
```

Exercise 1

1. Explain what the following variables refer to, and their scope:
    1. `Person`
    2. `person`
    3. `surname`
    4. `self`
    5. `age` (the function name)
    6. `age` (the variable used inside the function)
    7. `self.email`
    8. `person.email`

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Answer to exercise 1

1. 1. `Person` is a class defined in the global scope. It is a global variable.
   2. `person` is an instance of the `Person` class. It is also a global variable.
   3. `surname` is a parameter passed into the `__init__` method – it is a local variable in the scope if the `__init__` method.
   4. `self` is a parameter passed into each instance method of the class – it will be replaced by the instance object when the method is called on the object with the `.` operator. It is a new local variable inside the scope of each of the methods – it just always has the same value, and by convention it is always given the same name to reflect this.
   5. `age` is a method of the `Person` class. It is a local variable in the scope of the class.
   6. `age` (the variable used inside the function) is a local variable inside the scope of the `age` method.
   7. `self.email` isn't really a separate variable. It's an example of how we can refer to attributes and methods of an object using a variable which refers to the object, the `.` operator and the name of the attribute or method. We use the `self` variable to refer to an object inside one of the object's own methods – wherever the variable `self` is defined, we can use `self.email`, `self.age()`, etc..
   8. `person.email` is another example of the same thing. In the global scope, our person instance is referred to by the variable name `person`. Wherever `person` is defined, we can use `person.email`, `person.age()`, etc..

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```python
import datetime  # we will use this for date objects


class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

    def age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month,
                                 self.birthdate.day):
            age -= 1

        return age

```

Exercise 2

1. Rewrite the `Person` class so that a person's age is calculated for the first time when a new person instance is created, and recalculated (when it is requested) if the day has changed since the last time that it was calculated.

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Answer to exercise 2

1. Here is an example program:

```
import datetime

class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

        # This isn't strictly necessary, but it clearly introduces these attributes
        self._age = None
        self._age_last_recalculated = None

        self._recalculate_age()

    def _recalculate_age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month, self.birthdate.day):
            age -= 1

        self._age = age
        self._age_last_recalculated = today

    def age(self):
        if (datetime.date.today() > self._age_last_recalculated):
            self._recalculate_age()

        return self._age
```

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Exercise 3

1. Explain the differences between the attributes `name`, `surname` and `profession`, and what values they can have in different instances of this class:

```
class Smith:
    surname = "Smith"
    profession = "smith"

    def __init__(self, name, profession=None):
        self.name = name
        if profession is not None:
            self.profession = profession
```

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```
class Smith:
    surname = "Smith"
    profession = "smith"

    def __init__(self, name, profession=None):
        self.name = name
        if profession is not None:
            self.profession = profession
```

Answer to exercise 3

1. `name` is always an instance attribute which is set in the constructor, and each class instance can have a different name value. `surname` is always a class attribute, and cannot be overridden in the constructor – every instance will have a surname value of `Smith`. `profession` is a class attribute, but it can optionally be overridden by an instance attribute in the constructor. Each instance will have a profession value of `smith` unless the optional `surname` parameter is passed into the constructor with a different value.

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Exercise 4

1. Create a class called `Numbers`, which has a single class attribute called `MULTIPLIER`, and a constructor which takes the parameters `x` and `y` (these should all be numbers).
    1. Write a method called `add` which returns the sum of the attributes `x` and `y`.
    2. Write a class method called `multiply`, which takes a single number parameter `a` and returns the product of `a` and `MULTIPLIER`.
    3. Write a static method called `subtract`, which takes two number parameters, `b` and `c`, and returns `b - c`.
    4. Write a method called `value` which returns a tuple containing the values of `x` and `y`. Make this method into a property, and write a setter and a deleter for manipulating the values of `x` and `y`.

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Answer to exercise 4

1. Here is an example program:

```
class Numbers:
    MULTIPLIER = 3.5

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def add(self):
        return self.x + self.y

    @classmethod
    def multiply(cls, a):
        return cls.MULTIPLIER * a

    @staticmethod
    def subtract(b, c):
        return b - c

    @property
    def value(self):
        return (self.x, self.y)

    @value.setter
    def value(self, xy_tuple):
        self.x, self.y = xy_tuple

    @value.deleter
    def value(self):
        del self.x
        del self.y
```

Create a class called `Numbers`, which has a single class attribute called `MULTIPLIER`, and a constructor which takes the parameters `x` and `y` (these should all be numbers).

1. Write a method called `add` which returns the sum of the attributes `x` and `y`.
2. Write a class method called `multiply`, which takes a single number parameter `a` and returns the product of `a` and `MULTIPLIER`.
3. Write a static method called `subtract`, which takes two number parameters, `b` and `c`, and returns `b - c`.
4. Write a method called `value` which returns a tuple containing the values of `x` and `y`. Make this method into a property, and write a setter and a deleter for manipulating the values of `x` and `y`.

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Exercise 5

1. Create an instance of the `Person` class from example 2. Use the `dir` function on the instance. Then use the `dir` function on the class.
    1. What happens if you call the `__str__` method on the instance? Verify that you get the same result if you call the `str` function with the instance as a parameter.
    2. What is the type of the instance?
    3. What is the type of the class?
    4. Write a function which prints out the names and values of all the custom attributes of any object that is passed in as a parameter.

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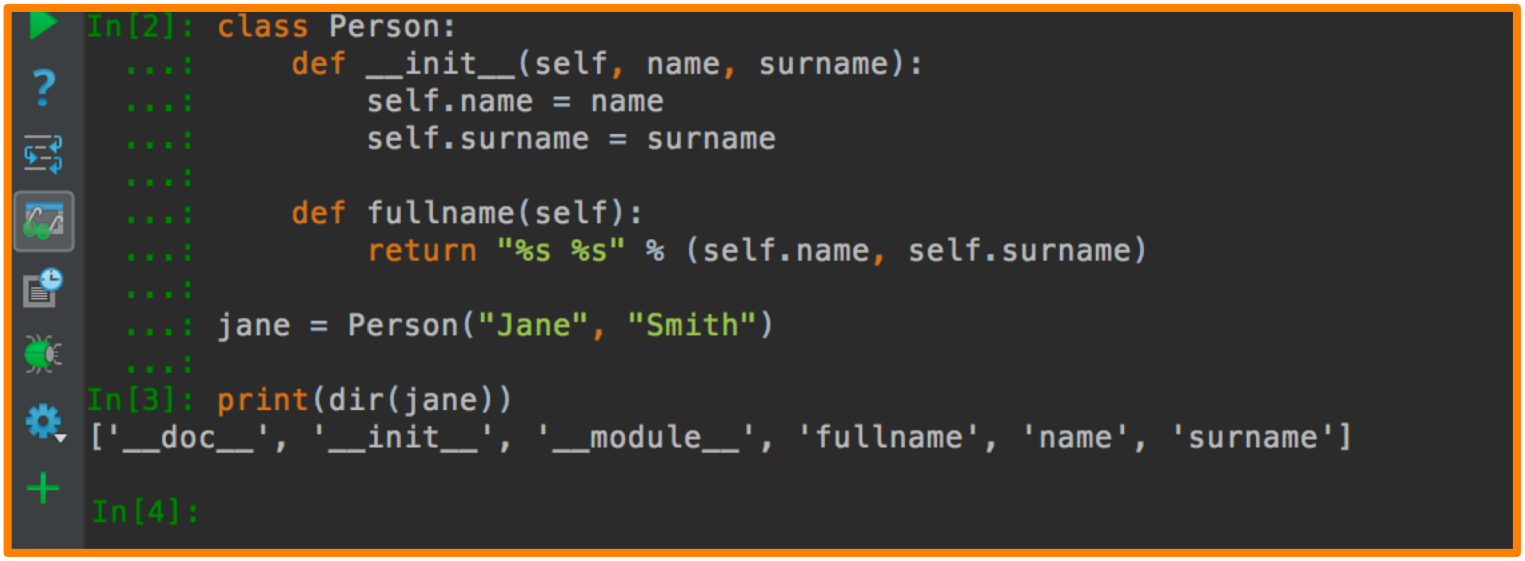

```
In[2]: class Person:
   ...:     def __init__(self, name, surname):
   ...:         self.name = name
   ...:         self.surname = surname
   ...:
   ...:     def fullname(self):
   ...:         return "%s %s" % (self.name, self.surname)
   ...:
   ...: jane = Person("Jane", "Smith")
   ...:
In[3]: print(dir(jane))
['__doc__', '__init__', '__module__', 'fullname', 'name', 'surname']

In[4]:
```

- Use function **dir** for inspecting objects: output list of the attributes and methods

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Answer to exercise 5

1. 1. You should see something like `'<__main__.Person object at 0x7fcb233301d0>'`.
   2. `<class '__main__.Person'>` – `__main__` is Python's name for the program you are executing.
   3. `<class 'type'>` – any class has the type `type`.
   4. Here is an example program:

```
def print_object_attrs(any_object):
    for k, v in any_object.__dict__.items():
        print("%s: %s" % (k, v))
```

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Exercise 6

1. Write a class for creating completely generic objects: its `__init__` function should accept any number of keyword parameters, and set them on the object as attributes with the keys as names. Write a `__str__` method for the class – the string it returns should include the name of the class and the values of all the object's custom instance attributes.

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Answer to exercise 6

1. Here is an example program:

```
class AnyClass:
    def __init__(self, **kwargs):
        for k, v in kwargs.items():
            setattr(self, k, v)

    def __str__(self):
        attrs = ["%s=%s" % (k, v) for (k, v) in self.__dict__.items()]
        classname = self.__class__.__name__
        return "%s: %s" % (classname, " ".join(attrs))
```

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REFERENCES

This lecture re-uses selected parts of the OPEN BOOK PROJECT

Learning with Python 3 (RLE)

http://openbookproject.net/thinkcs/python/english3e/index.html

available under GNU Free Documentation License Version 1.3)

- Version date: October 2012
- by Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers (based on 2nd edition by Jeffrey Elkner, Allen B. Downey, and Chris Meyers)
- Source repository is at https://code.launchpad.net/~thinkcspy-rle-team/thinkcspy/thinkcspy3-rle
- For offline use, download a zip file of the html or a pdf version from http://www.ict.ru.ac.za/Resources/cspw/thinkcspy3/

This lecture re-uses selected parts of the PYTHON TEXTBOOK

Object-Oriented Programming in Python

http://python-textbok.readthedocs.io/en/1.0/Classes.html#

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