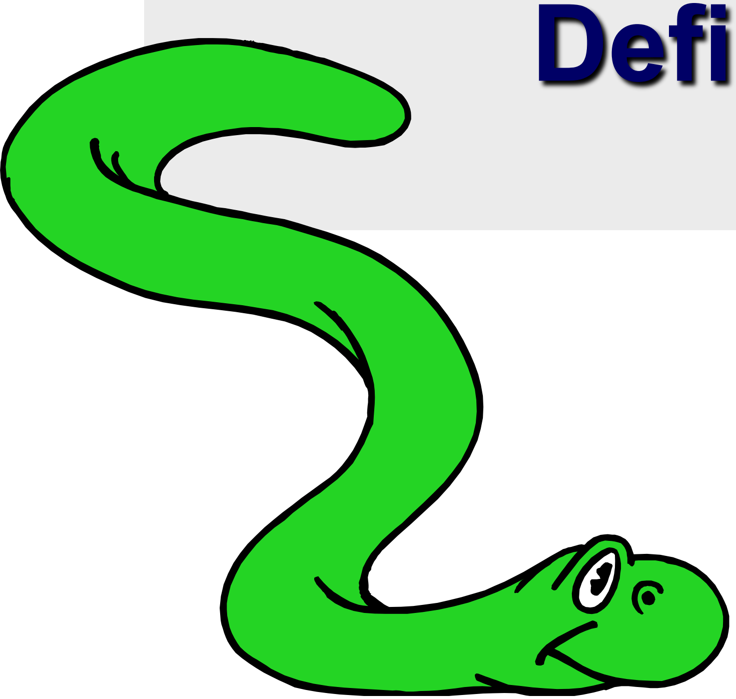
Object Oriented Programming in Python: Defining Classes



It’s all objects…

- Everything in Python is really an object.
  - We’ve seen hints of this already…

```
“hello”.upper()
list3.append(‘a’)
dict2.keys()
```

  - These look like Java or C++ method calls.
  - New object classes can easily be defined in addition to these built-in data-types.
- In fact, programming in Python is typically done in an object oriented fashion.

Defining a Class

- A *class* is a special data type which defines how to build a certain kind of object.
- The *class* also stores some data items that are shared by all the instances of this class
- *Instances* are objects that are created which follow the definition given inside of the class
- Python doesn’t use separate class interface definitions as in some languages
- You just define the class and then use it

Methods in Classes

- Define a *method* in a *class* by including function definitions within the scope of the class block
- There must be a special first argument ***`self`*** in *all* of method definitions which gets bound to the calling instance
- There is usually a special method called ***`__init__`*** in most classes
- We'll talk about both later…

A simple class def: *student*

```
class student:
 “““A class representing a
 student ”””
 def __init__(self,n,a):
     self.full_name = n
     self.age = a
 def get_age(self):
     return self.age
```

Creating and Deleting Instances

Instantiating Objects

- There is no “new” keyword as in Java.
- Just use the class name with ( ) notation and assign the result to a variable
- `__init__` serves as a constructor for the class. Usually does some initialization work
- The arguments passed to the class name are given to its `__init__()` method
- So, the __init__ method for student is passed “Bob” and 21 and the new class instance is bound to b:

```
b = student(“Bob”, 21)
```

Constructor: __init__

- An `__init__` method can take any number of arguments.
- Like other functions or methods, the arguments can be defined with default values, making them optional to the caller.

- However, the first argument `self` in the definition of __init__ is special…

Self

- The first argument of every method is a reference to the current instance of the class
- By convention, we name this argument ***`self`***
- In `__init__`, *`self`* refers to the object currently being created; so, in other class methods, it refers to the instance whose method was called
- Similar to the keyword *this* in Java or C++
- But Python uses *self* more often than Java uses *this*

Self

- Although you must specify `self` explicitly when *defining* the method, you don’t include it when *calling* the method.
- Python passes it for you automatically

Defining a method:

(this code inside a class definition.)

```
def set_age(self, num):
  self.age = num
```

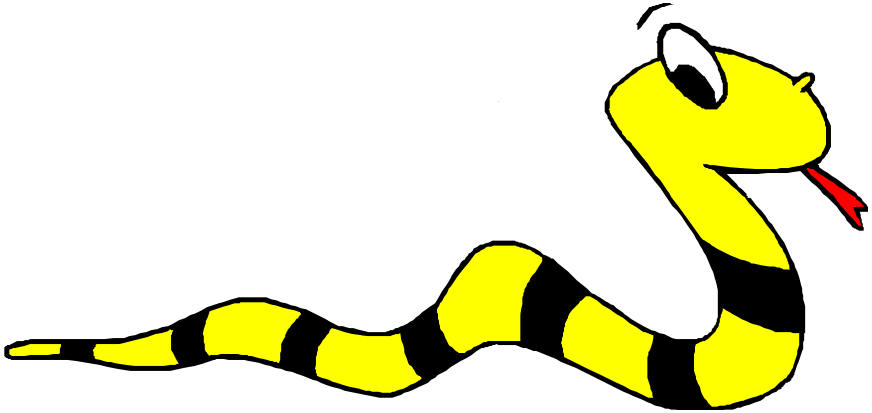
Calling a method:

```
>>> x.set_age(23)
```

Deleting instances: No Need to “free”

- When you are done with an object, you don’t have to delete or free it explicitly.
- Python has automatic garbage collection.
- Python will automatically detect when all of the references to a piece of memory have gone out of scope. Automatically frees that memory.
- Generally works well, few memory leaks
- There’s also no “destructor” method for classes

Access to Attributes and Methods



Definition of student

```
class student:
 “““A class representing a student
  ”””
 def __init__(self,n,a):
     self.full_name = n
     self.age = a
 def get_age(self):
     return self.age
```

Traditional Syntax for Access

```
>>> f = student(“Bob Smith”, 23)

>>> f.full_name # Access attribute
“Bob Smith”

>>> f.get_age() # Access a method
23
```

Accessing unknown members

- Problem: Occasionally the name of an attribute or method of a class is only given at run time…
- Solution:

```
getattr(object_instance, string)
```

- **`string`** is a string which contains the name of an attribute or method of a class
- **`getattr(object_instance, string)`** returns a reference to that attribute or method

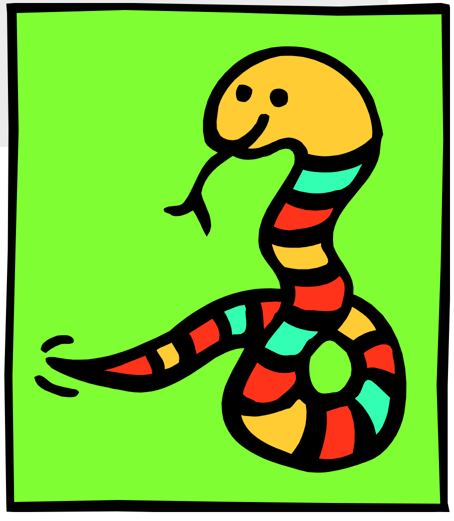
getattr(object_instance, string)

```
>>> f = student(“Bob Smith”, 23)
>>> getattr(f, “full_name”)
“Bob Smith”
>>> getattr(f, “get_age”)
 <method get_age of class
 studentClass at 010B3C2>
>>> getattr(f, “get_age”)() # call it
23
>>> getattr(f, “get_birthday”)
# Raises AttributeError – No method!
```

hasattr(object_instance,string)

```
>>> f = student(“Bob Smith”, 23)
>>> hasattr(f, “full_name”)
True
>>> hasattr(f, “get_age”)
True
>>> hasattr(f, “get_birthday”)
False
```

Attributes



Two Kinds of Attributes

- The non-method data stored by objects are called attributes
- *Data* attributes
  - Variable owned by a *particular instance* of a class
  - Each instance has its own value for it
  - These are the most common kind of attribute
- *Class* attributes
  - Owned by the *class as a whole*
  - *All class instances share the same value for it*
  - Called “static” variables in some languages
  - Good for (1) class-wide constants and (2) building counter of how many instances of the class have been made

Data Attributes

- Data attributes are created and initialized by an `__init__()` method.
  - Simply assigning to a name creates the attribute
  - Inside the class, refer to data attributes using **`self`**

    —for example, **`self.full_name`**

```
class teacher:
 “A class representing teachers.”
 def __init__(self,n):
     self.full_name = n
 def print_name(self):
     print self.full_name
```

Class Attributes

- Because all instances of a class share one copy of a class attribute, when *any* instance changes it, the value is changed for *all* instances
- Class attributes are defined *within* a class definition and *outside* of any method
- Since there is one of these attributes *per class* and not one *per instance*, they' re accessed via a different notation:
  - Access class attributes using `self.__class__.name` notation -- This is just one way to do this & the safest in general.

```
class sample:
    x = 23
   def increment(self):
      self.__class__.x += 1
```

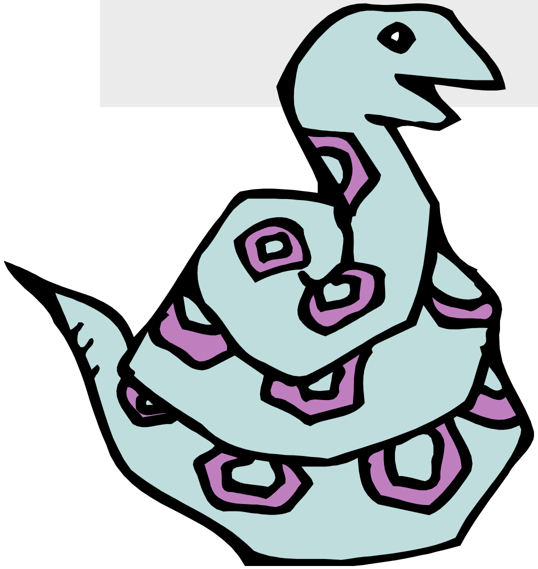
```
>>> a = sample()
>>> a.increment()
>>> a.__class__.x
24
```

Data vs. Class Attributes

```
class counter:
  overall_total = 0
       # class attribute
  def __init__(self):
      self.my_total = 0
        # data attribute
  def increment(self):
     counter.overall_total = \
     counter.overall_total + 1
     self.my_total = \
     self.my_total + 1
```

```
>>> a = counter()
>>> b = counter()
>>> a.increment()
>>> b.increment()
>>> b.increment()
>>> a.my_total
1
>>> a.__class__.overall_total
3
>>> b.my_total
2
>>> b.__class__.overall_total
3
```

Inheritance



Subclasses

- Classes can *extend* the definition of other classes
  - Allows use (or extension) of methods and attributes already defined in the previous one
- To define a subclass, put the name of the superclass in parens after the subclass' s name on the first line of the definition

```
    Class Cs_student(student):
```

  - Python has no 'extends' keyword like Java
  - Multiple inheritance is supported

Multiple Inheritance

- Python has two kinds of classes: old and new (more on this later)
- Old style classes use *depth-first, left-to-right* access
- New classes use a more complex, dynamic approach

```
class AO(): x = 0
class BO(AO): x = 1
class CO(AO): x = 2
class DO(BO,CO): pass

ao = AO()
bo = BO()
co = CO()
do = DO()
```

```
>>> from mi import *
>>> ao.x
0
>>> bo.x
1
>>> co.x
2
>>> do.x
1
>>>
```

http://cs.umbc.edu/courses/331/current/code/python/mi.py

Redefining Methods

- To *redefine a method* of the parent class, include a new definition using the same name in the subclass
  - The old code won't get executed
- To execute the method in the parent class *in addition to* new code for some method, explicitly call the parent's version of method

```
parentClass.methodName(self,a,b,c)
```

- The only time you ever explicitly pass 'self' as an argument is when calling a method of an ancestor

Definition of a class extending student

```
Class Student:
 “A class representing a student.”

  def __init__(self,n,a):
      self.full_name = n
      self.age = a

  def get_age(self):
      return self.age
--------------------------------------
Class Cs_student (student):
 “A class extending student.”

  def __init__(self,n,a,s):
      student.__init__(self,n,a) #Call __init__ for student
      self.section_num = s

  def get_age():       #Redefines get_age method entirely
      print “Age: ” + str(self.age)
```

Extending __init__

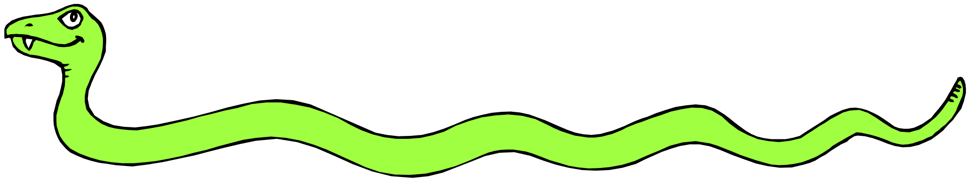
Same as redefining any other method…

- Commonly, the ancestor’s **`__init__`** method is executed in addition to new commands
- You’ll often see something like this in the **`__init__`** method of subclasses:

```
parentClass.__init__(self, x, y)
```

where parentClass is the name of the parent’s class

Special Built-In Methods and Attributes



Built-In Members of Classes

- Classes contain many methods and attributes that are always included
  - Most define automatic functionality triggered by special operators or usage of that class
  - Built-in attributes define information that must be stored for all classes.
- All built-in members have double underscores around their names:

```
__init__   __doc__
```

Special Methods

- E.g., the method `__repr__` exists for all classes, and you can always redefine it
- __repr__ specifies how to turn an instance of the class into a string
  - **`print f`** sometimes calls **`f.__repr__()`** to produce a string for object f
  - Typing **`f`** at the REPL prompt calls **`__repr__`** to determine what to display as output

Special Methods – Example

```
class student:
  ...
   def __repr__(self):
     return “I’m named ” + self.full_name
  ...

>>> f = student(“Bob Smith”, 23)
>>> print f
I’m named Bob Smith
>>> f
“I’m named Bob Smith”
```

Special Methods

- You can redefine these as well:

`__init__`	: The constructor for the class
`__cmp__`	: Define how == works for class
`__len__`	: Define how `len(` obj `)` works
`__copy__`	: Define how to copy a class

- Other built-in methods allow you to give a class the ability to use [ ] notation like an array or ( ) notation like a function call

Special Data Items

- These attributes exist for all classes.

  `__doc__` : Variable for documentation string for class

  `__class__` : Variable which gives you a reference to the class from any instance of it

  `__module__` : Variable which gives a reference to the module in which the particular class is defined

  __dict__ :The dictionary that is actually the namespace for a class (but not its superclasses)

- Useful:
  - **`dir(x)` returns a list of all methods and attributes defined for object x**

Special Data Items – Example

```
>>> f = student(“Bob Smith”, 23)

>>> print f.__doc__
A class representing a student.

>>> f.__class__
< class studentClass at 010B4C6 >

>>> g = f.__class__(“Tom Jones”,
 34)
```

Private Data and Methods

- Any attribute/method with two leading underscores in its name (but none at the end) is **private** and can’t be accessed outside of class
- Note: Names with two underscores at the beginning ***and the end*** are for built-in methods or attributes for the class
- Note: There is no ‘protected’ status in Python; so, subclasses would be unable to access these private data either