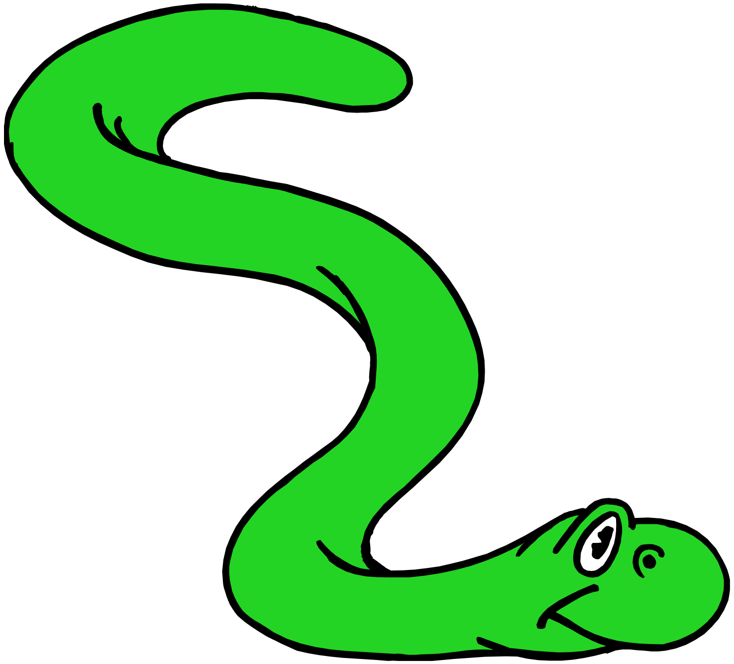
Intro to Python

- Defining classes
- Instantiating objects
- Access to attributes and methods
- Types of attributes
- Inheritance
- Built-in methods and attributes

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 the class.
- **Python doesn′t use separate class interface definitions as in some languages.**
  - You just define the class in the Python program…
  - … 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 <u>*all*</u> 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 definition: *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 (i.e. Python is not the same syntactically as Java).**
- **Merely use the class name with () notation and assign the result to a variable.**
- **`__init__` function serves as a constructor for the class. Usually does some initialization work (of course).**
- **The arguments passed to the class name are given to its `__init__()` method.**
  - So, the __init__ method for student is passed "Bob" and 21 here 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`***.
  - We could give it a different name, but we'd risk writing unreadable Python code…

- **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* **far 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

```python
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 an 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

- **Only need this when writing <u>very</u> extensible code**

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")()    # We can call this.
23

>>> getattr(f, "get_birthday")
      # Raises AttributeError - No method exists.
```

hasattr(object_instance,string)

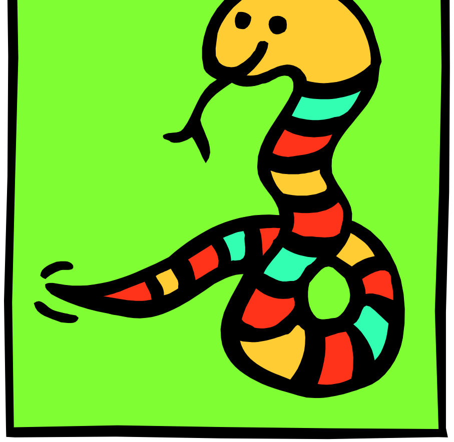
```
>>> f = Student("Bob Smith", 23)

>>> 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 instances of the class share the same value for it.*
  - Called ″static″ variables in some languages.
  - Good for
    - class-wide constants
    - 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
  - *outside* of any method

- **Since there is one of these attributes *per class* and not one *per instance*, they are accessed using a different notation:**
  - Access class attributes using `self.__class__.name` notation.

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

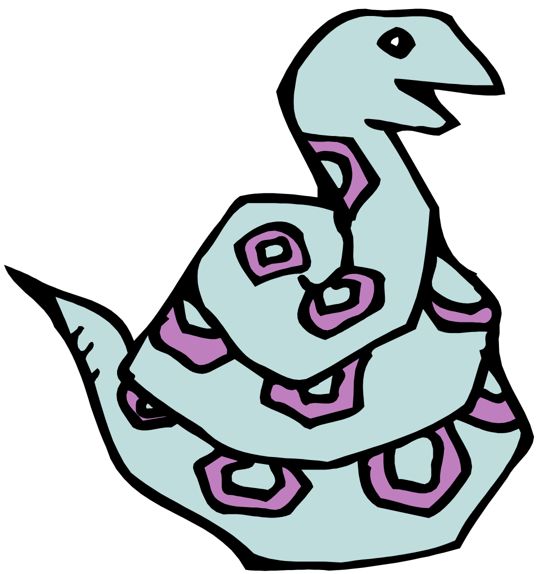
```
>>> a = Sample()
>>> a.increment()
>>> a.__class__.x
24
```

Data vs. Class Attributes

```python
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
```

```python
>>> 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

- **A class can *extend* the definition of another class**
  - Allows use (or extension) of methods and attributes already defined in the previous one.
  - New class: *subclass*. Original: *parent*, *ancestor* or *superclass*
- **To define a subclass, put the name of the superclass in parentheses after the subclass′s name on the first line of the definition.**

```
class AI_Student(Student):
```

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

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 the 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 AI_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(self):      #Redefines get_age method entirely
       print("Age: " + str(self.age))
```

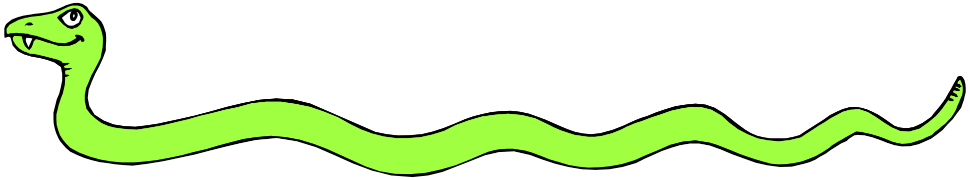
Extending __init__

- **Same as for 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 included by Python even if you don't define them explicitly.**
  - Most of these methods define automatic functionality triggered by special operators or usage of that class.
  - The 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

- **For example, the method `__repr__` exists for all classes, and you can always redefine it.**
- **The definition of this method 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.
  - If you type `f` at the prompt and hit ENTER, then you are also calling `__repr__` to determine what to display to the user as output.

Special Methods – Example

```
class Student:
     def __str__(self):
       return "I am %s aged %d" % (self.full_name, self.age)

     def __repr__(self):
       return "Student(%s, %d)" %  \
            (repr(self.full_name), repr(self.age))
    ...

>>> f = Student("Bob Smith", 23)
>>> print(f)
I am Bob Smith aged 23
>>> repr(f)
Student("Bob Smith", 23)
```

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 storing the documentation string for that class.

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

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

- **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 or method with two leading underscores in its name (but none at the end) is meant to be treated as private. It is not meant to be accessed outside of that 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.
  - Lastly:
    Unlike Java, this naming convention makes access of such attributes more difficult, but does not entirely hide them from users of the object (i.e., there is no strict implementation of “private” in Python)

Private-ish

```
class Student:
    """A class representing a student, but where the
    attributes are named in a private-ish kind of way."""
    def __init__(self, name, aage):
        self.__full_name = name
        self.__age = aage

    def get_age(self):
        return self.__age

     def __str__(self):
        return self.__full_name + " (" + str(self.__age) + ")"
```

```
>>> s1 = Student("Bob Smith", 23)

>>> print(s1)
Bob Smith (19)

>>> print(s1.__full_name)
<... snip ...>
AttributeError: 'Student' object has no attribute '__full_name'
```

Private-ish

```
class Student:
    """A class representing a student, but where the
    attributes are named in a private-ish kind of way."""
    def __init__(self, name, aage):
        self.__full_name = name
        self.__age = aage

    def get_age(self):
        return self.__age

     def __str__(self):
        return self.__full_name + " (" + str(self.__age) + ")"
```

```
>>> print(s1.__age)
<... snip ...>
AttributeError: 'Student' object has no attribute '__age'

>>> dir(s1)
['_Student__age', '_Student__full_name', '__class__', '__delattr__', ...

>>> print(s1._Student__age)    # :-(
23
```

Classes seem kinda clunky, but...

- **This would be to miss the main point**
- **That is:**
  - Python does **support** the class mechanism...
  - ... but more importantly **it also supports** a framework of classes and types ...
  - ... plus a pattern of typical object usage ...
  - ... where what matters most is that operations are supported on class/type instances under that typical usage.
  - This is sometimes called “duck typing”