Object-Oriented Programming in Python

(Taken and Adapted from the course notes of Dr. Greene of UCD School of Computer Science and Informatics, Dublin)

Classes and Objects

Object-Oriented Programming (OOP): A programming paradigm that involves designing programs around concepts represented as "objects"

- Python supports OOP through the provision of classes.
- Terminology
  - Class: A collection of functions and attributes, attached to a specific name, which represents an abstract concept.
  - Attribute: A named piece of data (i.e. variable associated with a class.
  - Object: A single concrete instance generated from a class

Instances of Classes

Classes can be viewed as factories or templates for generating new object instances.

Each object instance takes on the properties of the class from which it was created.

Instances of Classes

Abstract concept

Rectangle

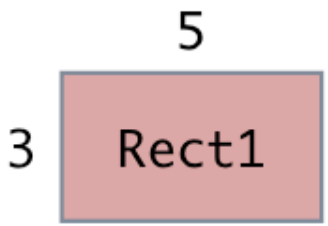
Attributes

- width
- height
- colour

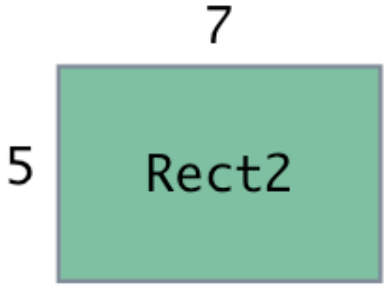
Functions

- area()

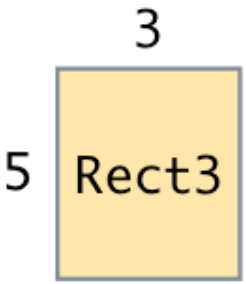
Multiple concrete instances



width=5
height=3
colour=(200,0,0)
area() -> 15



width=7
height=5
colour=(0,200,0)
area() -> 35



width=3
height=5
colour=(255,200,0)
area() -> 15

Creating Classes

Defining a class in Python is done using the class keyword, followed by an indented block with the class contents.

Class data attributes

```
class <Classname>:
   data1 = value1
   ...
   dataM = valueM

   def <function1>(self,arg1,...,argK):
         <block>
   ...
   def <functionN>(self,arg1,...,argK):
         <block>
```

Class member functions

Defining Functions in Classes

- A class definition block can include multiple functions.
- These represent the functionality or behaviors that are associated with the class.

```
>>> class Maths:
...     def subtract(self,i,j):
...         return i-j
...
...     def add(self,x,y):
...         return x+y
```

Argument (self) refers to the object itself

Calling Functions in Classes

- Using Class Functions from Outside a Class
  Functions are referenced by using the dot syntax:
  <objectName>.<methodName>()

```
>>> m = Maths()
>>> m.subtract(10,5)
5
>>> m.add(6,7)
13
```

No need to specify value for self, Python does this automatically

Calling Functions in Classes

- Using Class Functions from Inside a Class

When referring to functions from within a class, we must always prefix the function name with self

(e.g. self.subtract())

```
>>> class Maths:
...     def subtract(self,i,j):
...         return i-j
...
...     def testsub(self):
...         print self.subtract(8,4)
```

Tell Python to use function associated with this object

Attributes

Class attribute defined at top of class

```
>>> class Person:
...     company = "ucd"
...
...     def __init__(self):
...         self.age = 23
```

Instance attribute defined inside a class function.
The `self` prefix is always required.

```
>>> p1 = Person()
>>> p2 = Person()
>>> p1.age = 35
>>> print p2.age
23
```

Change to instance attribute age affects only the associated instance (p2)

```
>>> p1 = Person()
>>> p2 = Person()
>>> p1.company = "ibm"
>>> print p2.company
'ibm'
```

Change to class attribute company affects all instances (p1 and p2)

Constructor

- When an instance of a class is created, the class constructor function is automatically called.
- The constructor is always named __init__()
- It contains code for initializing a new instance of the class to a specific initial state (e.g. setting instance attribute values).

```
>>> class Person:
...     def __init__( self, s ):
...         self.name = s
...
...     def hello( self ):
...         print "Hello", self.name
```

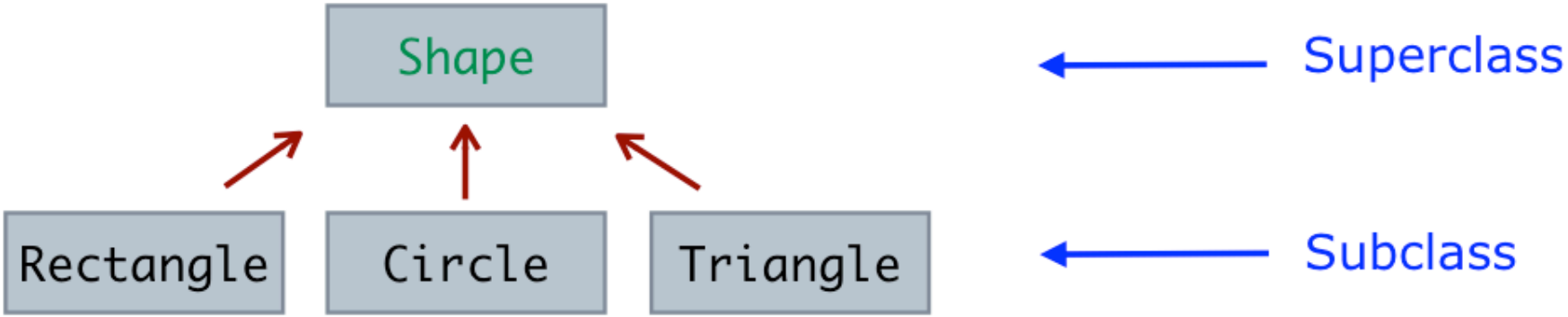
Constructor function taking initial value for instance attribute name

```
>>> t = Person("John")
>>> t.hello()
Hello John
```

Calls __init__() on Person

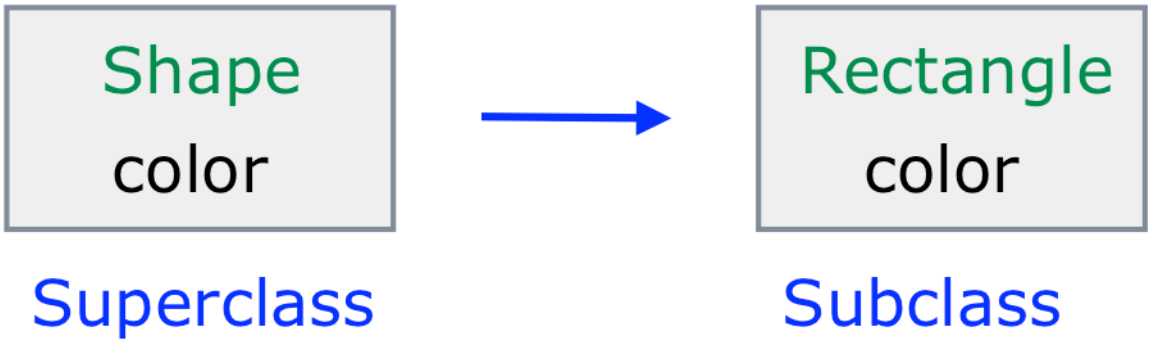
Inheritance

Class inheritance is designed to model relationships of the type "x **is a** y" (e.g. "a triangle is a shape")



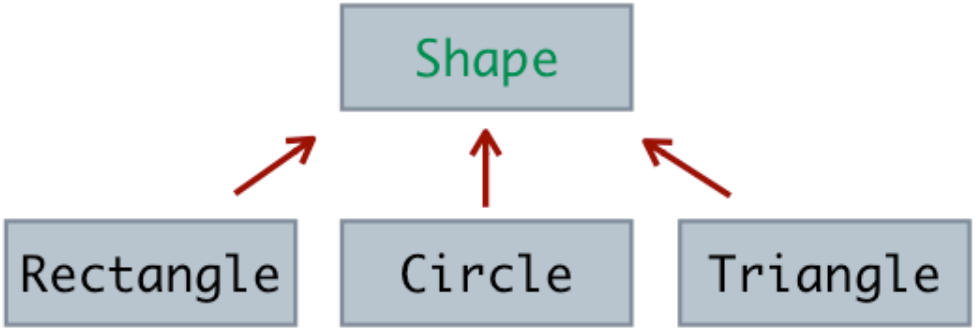
Inheritance

The functions and attributes of a superclass are inherited by a subclass.



An inherited class can override, modify or augment the functions and attributes of its parent class.

Creating Subclasses



Superclass

```
>>> class Shape:
...     pass
```

Name of superclass

Subclass

```
>>> class Rectangle(Shape):
...     def area(self):
            return self.width*self.height
```

Simple superclass

```
>>> class Shape:
...     def __init__( self ):
...         self.color = (0,0,0)
```

Simple subclass inheriting from Shape

```
>>> class Rectangle(Shape):
...     def __init__( self, w, h ):
...         Shape.__init__( self )
...         self.width = w
...         self.height = h
...
...     def area( self ):
...         return self.width*self.height
```

Need to call constructor function in superclass

```
>>> r1 = Rectangle( 10, 5 )
>>> print r1.width
10
>>> print r1.height
5
>>> print r1.area()
50
>>> print r1.color
(0, 0, 0)
```

Construct object instance

Inherited attribute

Overriding

When inheriting from a class, we can alter the behavior of the original superclass by "overriding" functions (i.e. declaring functions in the subclass with the same name).

Functions in a subclass take precedence over functions in a superclass.

Overriding

```
class Counter:
    def __init__(self):
        self.value = 0

    def increment(self):
        self.value += 1
```

Overriding

```
class CustomCounter(Counter):
    def __init__(self,size):
        Counter.__init__(self)
        self.stepsize = size

    def increment(self):
        self.value += self.stepsize
```

```
>>> cc = CustomCounter(4)
>>> cc.increment()
>>> cc.print_current()
Current value is 4
```

Calls `increment()` on `CustomCounter` not `Counter`

Composition

Classes can be built from other smaller classes,allowing us to model relationships of the type "x **has a** y" (e.g. a department has students).

```
class Department:
   def __init__( self ):
      self.students = []

   def enroll( self, student ):
      self.students.append(student)
```

```
class Student:
   def __init__( self,last,first ):
      self.lastname = last
      self.firstname = first
```

```
>>> compsci = Department()
>>> compsci.enroll( Student( "Smith", "John" ) )
>>> compsci.enroll( Student( "Murphy", "Alice" ) )
```

Create Student instances and add to Department instance

```
>>> for s in compsci.students:
...     print "%s %s" % (s.firstname,s.lastname)
...
John Smith
```

Polymorphism

Two objects of different classes but supporting the same set of functions or attributes can be treated identically.

The implementations may differ internally, but the outward "appearance" is the same.

Polymorphism

Two different classes that contain the function area()

```
class Rectangle(Shape):
    def __init__(self, w, h):
      Shape.__init__(self)
        self.width = w
        self.height = h

    def area(self):
        return self.width*self.height
```

```
class Circle(Shape):
    def __init__(self, rad):
      Shape.__init__(self)
        self.radius = rad

    def area(self):
        return math.pi*(self.radius**2)
```

Instances of the two classes can be treated identically...

```
>>> l = []
>>> l.append( Rectangle(4,5) )
>>> l.append( Circle(3) )
>>> for someshape in l:
...     print someshape.area()
...
20
28.2743338823
```

Result of area() in Rectangle →

Result of area() in Circle →