Introduction To Python

Week 6: More On Functions And Modules

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Namespace

- Recall some of the import games we played:
  - import pickle
  - import pickle as foofoo
  - from pickle import load
  - from pickle import load as foo
  - from pickle import *
- Names of variables, functions, objects, methods, etc. exist within ***namespaces***.
- What a thing is depends on where you are in a code.

Simple Illustration

```
def myfunc( x ) :
    a = 3
    c = x
    d = 0
    print a, c, d

if __name__ == '__main__' :
    a = 4
    c = 13
    d = 42
    myfunc( 17 )
    print a, c, d
```

What does this print?

Global Namespace

```
3 17 0
4 13 42
```

a, c, d in **myfunc()** namespace

a, c, d in ***global*** namespace

The variables a, c, and d may have the same names, but they are separate entities in each space.

Access Global Namespace

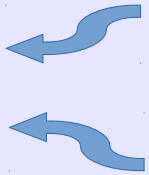
```
def myfunc( x ) :
    global c
    a = 3
    c = x
    d = 0
    print a, c, d

if __name__ == '__main__' :
    a = 4
    c = 13
    d = 42
    myfunc( 17 )
    print a, c, d
```

Declare c to be in global namespace

Now what does this print?

Values from Different Namespaces

```
3 17 0
4 17 42
```



a, d in myfunc() namespace, but c in global namespace.

a, c, d in ***global*** namespace

Note: there is also the ***built-in*** namespace, which is the namespace reserved for the Python language keywords, functions, etc.

Using **global**

- Some would say NEVER!
- May simplify data handling - i.e. shorter argument lists, dealing with problem setup values, etc.
- May have bad side effects - i.e. new programmer is unaware that other routines may change the value.
- Up to programmer to use it well as the case demands.

Dealing With Errors

- Here is some bad code:

```
y = 0.0

def myfunc( x ) :
    return badfunc( x )

def badfunc( x ) :
    global y
    return x / y

if __name__ == '__main__' :
   print myfunc( 42.0 )
```

- How to anticipate errors and respond?

If It Runs, It Dies!

```
>>>

Traceback (most recent call last):
  File "C:/Users/jalupo/Documents/Projects/Presentations/Topical/Python/
        REU-Course/W6 - 02 Jul/exceptions.py", line 11, in <module>
    print myfunc( 42.0 )
  File "C:/Users/jalupo/Documents/Projects/Presentations/Topical/Python/
        REU-Course/W6 - 02 Jul/exceptions.py", line 4, in myfunc
    return badfunc( x )
  File "C:/Users/jalupo/Documents/Projects/Presentations/Topical/Python/
        REU-Course/W6 - 02 Jul/exceptions.py", line 8, in badfunc
    return x / y
ZeroDivisionError: float division by zero
>>>
```

Was called by

Was called by

Error Location

Nature of the error

Do Error Checking?

- How and where to handle the error?
- Put a conditional check in badfunc()?

```
def badfunc( x ) :
    global y
    if y != 0.0 :
        return x / y
    return ????
```

- Problem is, what to return, and how to handle in the caller?

Using Error Code or Flag

```
def badfunc( x ) :
    global y
    if y != 0.0 :
        return x / y, 0
    else :
        return 0.0, 1
```

What if programmer forgets to check flag?

Check Error Return?

myfunc() would have to look something like this?

```
def myfunc( x ) :
    tmp, ec = badfunc( x )
    if ec :
        return 0.0
    else :
        return tmp
```

Will the caller be happy with 0.0 as an error result?

Exceptions: The Elegant Solution

```
y = 0

def myfunc( x ) :
    try:
        return badfunc( x )
    except ZeroDivisionError:
        print "Ooops: Bad Ol' divide-by-zero error!"

def badfunc( x ) :
    global y
    return x / y

if __name__ == '__main__' :
   print myfunc( 42.0 )
```

Prepare for something bad to happen

Watch for divide by zero ***exception*** name.

Action if ***exception*** occurs.

Trapping Errors

try alerts Python that errors, called ***exceptions***, may occur (be ***raised***). The syntax is:

```
try :
    statement block
except exception :
    statement block
```

The **try** statement block is executed. If an exception is ***raised***, and it matches **exception**, the **except** statement block is executed. If not matched, Python will traverse up the call chain until a match is found, or the top level exception handler is reached.

Chose the Proper Level

The example produces output that looks like this:

```
Ooops: Bad Ol' divide-by-zero error!
None
```

- Not generally a good idea to have numerical values set to **None**.
- The goal should be trap exeptions at the level were program can react best (i.e. retry, save data, give other meaningful information).

Move **except** Up a Level

```
y = 0

def myfunc( x ) :
    return badfunc( x )

def badfunc( x ) :
    global y
    return x / y

if __name__ == '__main__' :
    try:
       print myfunc( 42.0 )
    except ZeroDivisionError:
        print "Ooops: Bad Ole' divide-by-zero-error!"
```

Deal With Multiple Errors

```
try :
    statement block
except ZeroDivisionError :
    statement block
except IOError :
    statement block
except (RunTimeError, TypeError) :
    statement block
finally :
    statement block
```

- This allows appropriate actions for each type of error/s.
- **finally** is special - it's statement block is always executed, even if exception is not caught here. It's statement block is executed, then the search for a handler goes up the call the tree.

Legal, But Not Recommended

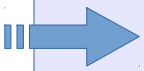
```
try :
    statement block
except :
    statement block
```

- Any error is caught
- But, this can disguise a programming error as something else.

Exception Details

- Exceptions represent objects, so you may be able to get more info:

```
fname = 'foo.txt'
try:
   f = open(fname,'r')
except IOError as e:
   print e.errno
   print fname, ':', e.strerror
```



```
2
foo.txt : No such file or directory
```

What Exception To Check For?

- The documentation for most functions includes exceptions that may occur.
- **open()**: If the named file can't be opened, it raises the IOError exception. This fact was used to create the previous example.
- ***built-in*** exception list. For instance:

  https://docs.python.org/2/library/exceptions.html

What exceptions are raised by these other functions we've used: chr(), range(), raw_input()

Raise An Exception

- **raise** ExceptionName allows direct control

```
y = 0

def myfunc( x ) :
    return badfunc( x )

def badfunc( x ) :
    global y
    if y == 0.0 :
        raise ValueError('Oh, Oh. Y is 0 in badfunc()')
    return x / y

if __name__ == '__main__' :
    try:
       print myfunc( 42.0 )
    except ValueError as n:
        print n
```

Oh, Oh. Y is 0 in badfunc()

Special Case

Use of raise without an exception is allowed in one special case:

```
try :
    statement block
except :
    statement block
    raise
```

Do some error handling.

Raises same exception for someone up the call chain to handle.

50,000 Ft Over-flight of Objects

- Encapsulates data and methods.
- An object can inherit from another.

Tricycle
three wheels
chain drive
pedals

Bicycle
two wheels
chain drive
pedals

Motor Bicycle
two wheels
chain drive
pedals
electric motor

Simple Example: A Point

- A point could have ***attributes***:
  - Coordinates
  - Mass (physics)
  - Color
  - Charge
- Computed relationships, such as:
  - Vector between two points
  - Distance between two points

A Class with Coordinate Attributes

```
class Point :
    x = 5.
    y = 42.
    z = -10.

p1 = Point
p2 = Point
p1.x = 7.
print p1.x, p2.x
```

Creates a class object named Point

p1 and p1 are bound to same object

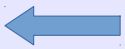
7.0 7.0

Technically, **p1** and **p2** are bound to Point - sort of aliases

Power of **Instantiation**

```
class Point :
    x = 5.
    y = 42.
    z = -10.

p1 = Point()
p2 = Point()
p1.x = 7.
print p1.x, p2.x
```

A class object named Point



p1 and p1 instantiate Point objects

7.0 5.0

x, y, and z become ***attributes*** of the class Point instances p1 and p2 - unique objects.

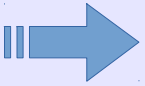
Define A Class Method

```
def getCoords( self ) :
    return self.x, self.y, self.z
```

The self keyword refers to the object instance.

Example

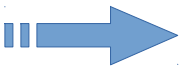
```
class Point :
   x = 5.0
   y = 42.0
   z = -10.0

   def getCoord ( self ) :
       return self.x, self.y, self.z

if __name__ == '__main__' :
    p1 = Point()
    p2 = Point()
    p1.x = 7.0
    print p1.getCoord()
    print p2.getCoord()
```



```
(7.0, 42.0, -10.0)
(5.0, 42.0, -10.0)
```

Initializer

```
class Point :

   def __init__( self, x = 0., y = 0., z = 0 )
       self.x = x
       self.y = y
       self.z = z

   def getCoord ( self ) :
       return self.x, self.y, self.z

if __name__ == '__main__' :
    p1 = Point()
    p2 = Point(10.,20.,30.)
    print p1.getCoord()
    print p2.getCoord()
```



```
(0.0, 0.0, 0.0)
(10.0, 20.0, 30.0)
```

Distance Between 2 Points

```
from math import sqrt

class Point:

    def __init__( self, x = 0., y = 0., z = 0. ) :
        self.x = x
        self.y = y
        self.z = z

    def getCoord( self ) :
        return self.x, self.y, self.z

    def distance( self, other ) :
        x, y, z = other.getCoord()
        d2 = (self.x - x)**2 + (self.y - y)**2 + (self.z - z)**2
        return sqrt( d2 )

if __name__ == '__main__' :
    p1 = Point()
    p2 = Point(10.0,20.,30.)
    print p1.distance( p2 )
```

Default to Origin

37.4165738677

Combined Example

```
class Point :
    import math
    def __init__( self, x=0., y=0., z=0. ) :
        self.x = x
        self.y = y
        self.z = z
    def setCoords( self, x, y, z ) :
        self.x = x
        self.y = y
        self.z = z
    def getCoords( self ) :
        return self.x, self.y, self.z
    def distance( self, other ) :
        x, y, z = other.getCoords()
        d2 = (self.x - x)**2 + (self.y - y)**2 + (self.z - z) **2
        return self.math.sqrt( d2 )
    def vector( self, other ) :
        return ( other.getX() - self.x, other.getY() \
                    - self.y, other.getZ() - self.z )
```

```
if __name__ == '__main__' :
    p1 = Point(1.,2.,3.)
    p2 = Point()
    p3 = Point(4.,5.,6.)
    print p1.getCoords()
    print p2.getCoords()
    print p3.getCoords()
    print p2.distance( p3 )
    print p1.vector( p3 )
    print p3.vector( p1 )
```

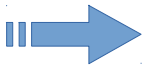
```
(1.0, 2.0, 3.0)
(0.0, 0.0, 0.0)
(4.0, 5.0, 6.0)
8.77496438739
(3.0, 3.0, 3.0)
(-3.0, -3.0, -3.0)
```

Add Methods

- Vector Dot Product
- Vector Cross Product

Inheritance

```
class Point :
   x = 5.0
   y = 42.0
   z = -10.0

   def getCoord ( self ) :
       return self.x, self.y, self.z

class Meteor(Point) :
    vx = 1.e+5
    vy = - 80.0
    vz = 250.

    def getVelocity( self ) :
        return self.vx, self.vy, self.vz

if __name__ == '__main__' :
    m1 = Meteor()
    print m1.getCoord()
    print m1.getVelocity()
```



```
(0.0, 0.0, 0.0)
(100000.0, -80.0, 250.0)
```

What Next?

- We've covered the basic concepts, and enough tools to write a useful program, or read an existing one.
- Go over some useful standard modules?
  - The module: os, sys
  - Using python as a shell scripting tool?
- Adding extension modules?
    - numpy, scipy, biopython, graphics
- Serious program development?
  - Conway Game of Life - cellular automata
  - Laplace heat equation solver - PDE solver
- Declare victory and leave the field?