

Functions & modules

Functions

Python can be both *procedural* (using functions) and *object oriented* (using classes)

[We do objects on Wednesday, but much of the function stuff now will also be applicable.]

Functions looks like:

```
def function_name(arg1, arg2, ..., kw1=v1, kw2=v2, kw3=v3...)
```

argX are *arguments*

required

(and sequence is important)

kwX are *keywords*

optional

(sequence unimportant; vals act like defaults)

Functions

You can name a function anything you want as long as it:

- contains only numbers, letters, underscore
- does not start with a number
- is not the same name as a *built-in* function (like print)

There is no difference between *functions* and *procedures*:

unlike, say in, IDL, in Python
functions that return nothing
formally, still return **None**

```
>>> def addnums(x,y):
        return x + y
>>> addnums(2,3)
5
>>> print addnums(0x1f,3.3)
34.3
>>> print addnums("a","b")      # oh no!
ab
>>> print addnums("cat",23232)
TypeError: cannot concatenate 'str' and 'int' objects
```

Unlike in C, we cannot declare what type of variables are required by the function.

```
>>> def addnums(x,y):
    if (not (isinstance(x,float) or isinstance(x,int) or isinstance(x,long))) or \
        (not (isinstance(y,float) or isinstance(y,int) or isinstance(y,long))):
        print "I cannot add these types (" + str(type(x)) + "," + str(type(y)) + ")"
        return
    return x + y
>>> print addnums(2,3.0)
5.0
>>> print addnums(1,"a")
I cannot add these types (<type 'int'>,<type 'str'>) together
None
>>>
```

scope

```
>>> addnums
<function addnums at 0x103767848>
>>> type(addnums)
<type 'function'>
>>> x = 2
>>> print addnums(5,6)
11
>>> print x
2
```

Python has it's own local variables list.
x is not modified globally

```
>>> def numop(x,y):
    x *= 3.14
    return x + y
>>> x = 1
>>> print numop(x,3)
6.14
>>> print x
1
```

scope

...unless you specify that it's a global variable

```
>>> def numop(x,y):  
    x *= 3.14  
    global a  
    a += 1  
    return x + y, a  
>>> a = 1  
>>> numop(1,1)  
(4.1400000000000006, 2)  
>>> numop(1,1)  
(4.1400000000000006, 3)  
>>> s, b = numop(1,1)  
>>> print s  
4.14  
>>> print b  
4
```

Note: we can return whatever we want (dictionary, tuple, lists, strings, etc.). This is really awesome...

keywords

```
>>> def numop1(x,y,multiplier=1.0,greetings="Thank you for your inquiry."):
...     if greetings is not None:
...         print greetings
...     return (x + y)*multiplier
>>> numop1(1,1)
Thanks for your inquiry.
2.0
>>> numop1(1,1,multiplier=-0.5,greetings=None)
-1.0
```



keywords are a natural way
to grow new functionality
without "breaking" old code

`*arg, **kwargs` captures unspecified args and keywords

```
def cheeseshop(kind, *arguments, **keywords):  
    print "-- Do you have any", kind, "?"  
    print "-- I'm sorry, we're all out of", kind  
    for arg in arguments: print arg  
    print "-" * 40  
    keys = keywords.keys()  
    keys.sort()  
    for kw in keys: print kw, ":", keywords[kw]
```

```
>>> cheeseshop("Limburger", "It's very runny, sir.",  
               "It's really very, VERY runny, sir.",  
               shopkeeper='Michael Palin',  
               client="John Cleese",  
               sketch="Cheese Shop Sketch")  
-- Do you have any Limburger ?  
-- I'm sorry, we're all out of Limburger  
It's very runny, sir.  
It's really very, VERY runny, sir.  
-----  
client : John Cleese  
shopkeeper : Michael Palin  
sketch : Cheese Shop Sketch
```

<http://docs.python.org/tutorial/controlflow.html#keyword-arguments>

Documentation: Just the Right thing to Do *and Python makes it dead simple*

Docstring: the first unassigned string in a function
(or class, method, program, etc.)

```
def numop1(x,y,multiplier=1.0,greetings="Thank you for your inquiry."):
    """ numop1 -- this does a simple operation on two numbers.
    We expect x,y are numbers and return x + y times the multiplier
    multiplier is also a number (a float is preferred) and is optional.
    It defaults to 1.0.
    You can also specify a small greeting as a string.
    """
    if greetings is not None:
        print greetings
    return (x + y)*multiplier
>>>
```

...accessing documentation within the interpreter

```
>>> help(numop1)    # or numop1? in ipython
```

```
Help on function numop1:
```

```
numop1(x, y, multiplier=1.0, greetings='Thank you for your inquiry.')
```

```
    Purpose: does a simple operation on two numbers.
```

```
    Input: We expect x,y are numbers
```

```
           multiplier is also a number (a float is preferred) and is optional.
```

```
           It defaults to 1.0. You can also specify a small greeting as a string.
```

```
    Output: return x + y times the multiplier
```

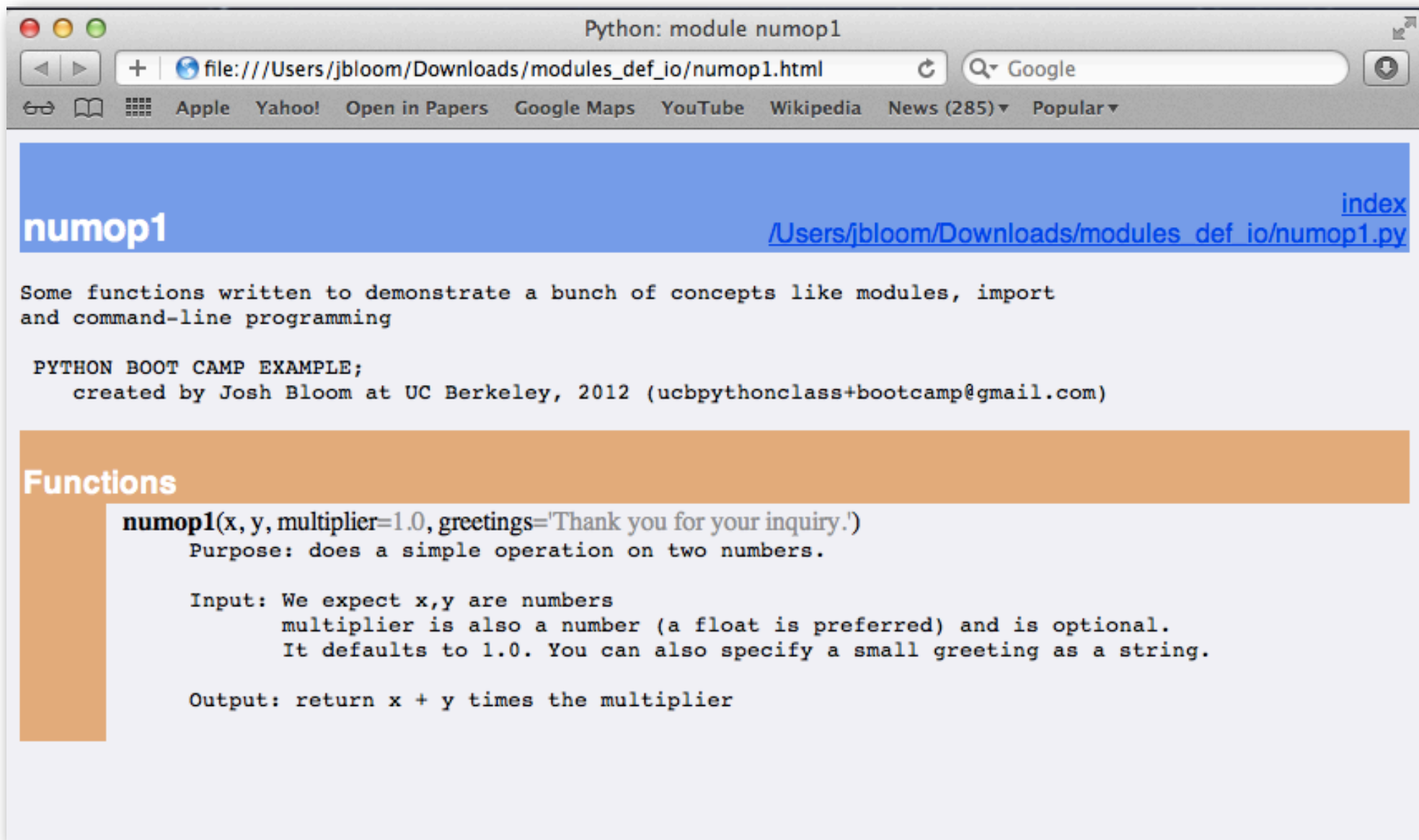
nice looking webpage documentation

assume that function is in file numop1.py

```
BootCamp> pydoc -w numop1
```

```
wrote numop1.html
```

```
BootCamp>
```



Modules

Organized units (written as files) which contain functions, statements and other definitions

Any file ending in `.py` is treated as a module
(e.g., `numop1.py`, which names and defines a function `numop1`)

Modules: own global names/functions so you can name things whatever you want there and not conflict with the names in other modules

file: numfun1.py

```
"""
small demo of modules
"""
def numop1(x,y,multiplier=1.0,greetings="Thank you for your inquiry."):
    """ numop1 -- this does a simple operation on two numbers.
    We expect x,y are numbers and return x + y times the multiplier
    multiplier is also a number (a float is preferred) and is optional.
    It defaults to 1.0.
    You can also specify a small greeting as a string.
        if greetings is not None:
            print greetings
    return (x + y)*multiplier
```

import *module_name*
gives us access to that module's functions

```
>>> import numfun1
>>> numfun1.numop1(2,3,2,greetings=None)
10
>>> numop1(2,3,2,greetings=None)
NameError: name 'numop1' is not defined
>>>
```

file: numfun2.py

```
"""
small demo of modules
"""
print "numfun2 in the house"
x    = 2
s    = "spamm"
```

} do some stuff and set some variables

```
def numopl(x,y,multiplier=1.0,greetings="Thank you for your inquiry."):
    """
    Purpose: does a simple operation on two numbers.

    Input: We expect x,y are numbers
           multiplier is also a number (a float is preferred) and is optional.
           It defaults to 1.0. You can also specify a small greeting as a string.

    Output: return x + y times the multiplier
    """
    if greetings is not None:
        print greetings
    return (x + y)*multiplier
```

```
>>> import numfun2
numfun2 in the house
>>> import numfun2          # numfun2 is already imported...do nothing
>>>
>>> print numfun2.x, numfun2.s
2, 'spamm'
>>> s = "eggs" ; print s, numop2.s
'eggs', 'spamm'
>>> numop2.s = s
>>> print s, numop2.s
'eggs', 'eggs'
>>> exit()
```

bring some of module's functions into the current namespace:

```
from module_name import function_name  
from module_name import variable  
from module_name import variable, function_name1,  
function_name2, ...
```

```
>>> from numfun2 import x, numop1  
numfun2 in the house  
>>> x == 2  
True  
>>> numop1(2,3,2,greetings=None)  
5  
>>> s  
NameError: name 's' is not defined  
>>> numfun2.x  
NameError: name 'numfun2' is not defined
```

Renaming a function (or variable) for your namespace:

`from module_name import name as my_name`

```
>>> from numfun2 import s as my_fav_food
>>> from numfun2 import numop1 as wicked_awesome_adder
>>> print my_fav_food
'spamm'
>>> wicked_awesome_adder(2,3,1)
5
```

Kitchen-Sinking It

`from module_name import *`

```
>>> from numfun2 import *
>>> print numop1(x,3,1)
5
```

This is convenient in the interpreter, but considered bad coding style. It pollutes your namespace.

Built-In Modules

give access to the full range of what Python can do

For example,

sys *exposes interpreter stuff & interactions
(like environment and file I/O)*

os *exposes platform-specific OS functions
(like file statistics, directory services)*

math *basic mathematical functions & constants*

These are super battle tested and close to the optimal way for doing things within Python

Help on built-in module sys:

NAME

sys

FILE

(built-in)

MODULE DOCS

<http://www.python.org/doc/2.7.3/lib/module-sys.html>

DESCRIPTION

This module provides access to some objects used or maintained by the interpreter and to functions that interact strongly with the interpreter.

Dynamic objects:

argv -- command line arguments; argv[0] is the script pathname if known

path -- module search path; path[0] is the script directory, else ''

modules -- dictionary of loaded modules

displayhook -- called to show results in an interactive session

excepthook -- called to handle any uncaught exception other than SystemExit
To customize printing in an interactive session or to install a custom top-level exception handler, assign other functions to replace these.

file: getinfo.py

```
import os
import sys

def getinfo(path="."):
    """
    Purpose: make simple use of os and sys modules
    Input: path (default = "."), the directory you want to list
    """
    print "You are using Python version ",
    print sys.version
    print "-" * 40
    print "Files in the directory " + str(os.path.abspath(path)) + ":"
    for f in os.listdir(path): print f
```

os.listdir() - return a dictionary of all the file names
in the specified directory

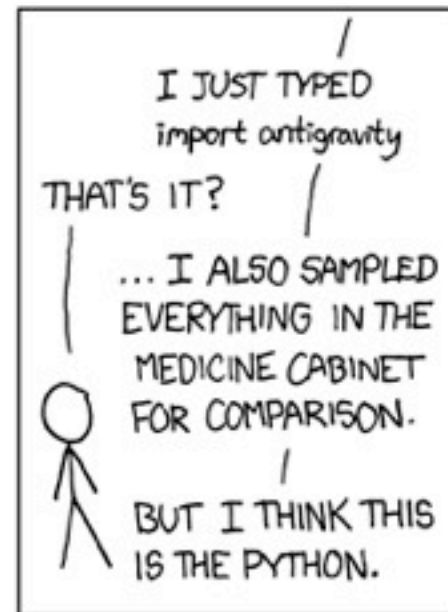
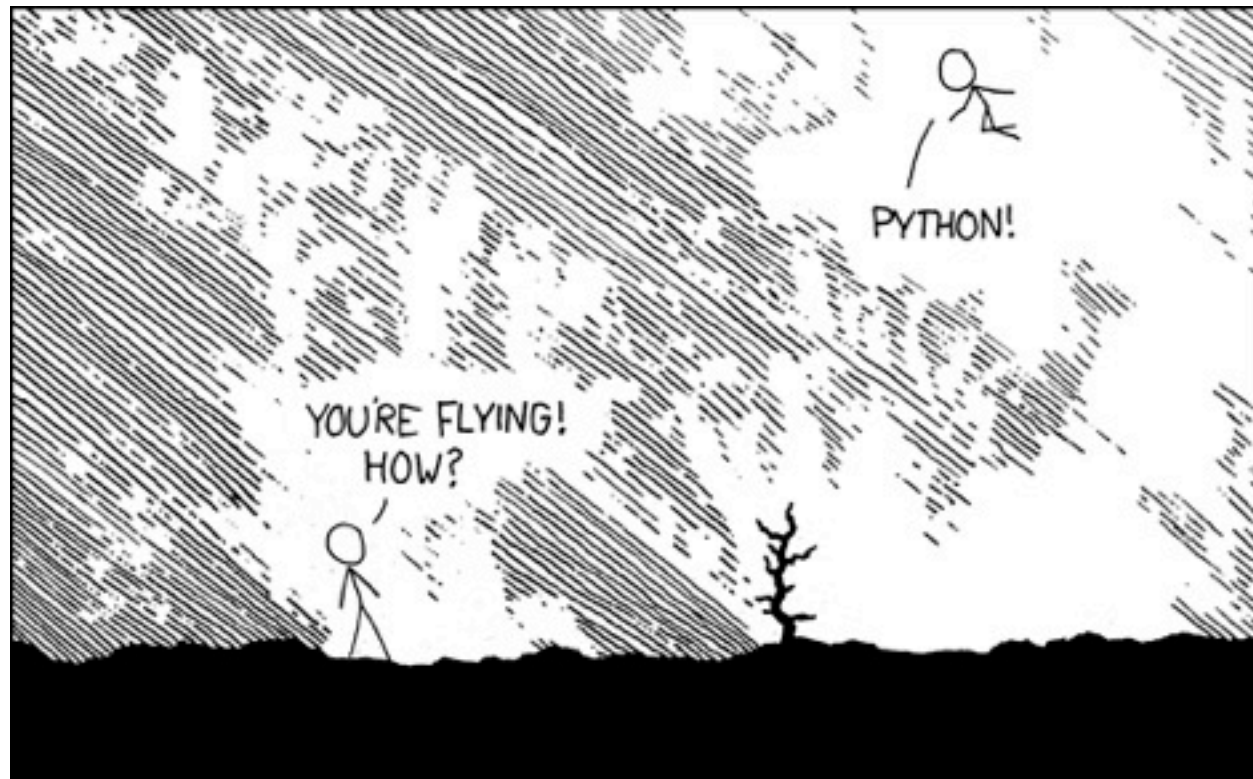
sys.version() - string representation of the Python
(and gcc) version

os.path.abspath() - translation of given pathname to
the absolute path (operating system-specific)



	Convert Python objects to streams of bytes and back (with different constraints).
<code>math</code>	Mathematical functions (<code>sin()</code> etc.).
<code>md5</code>	Deprecated: RSA's MD5 message digest algorithm.
<code>mhlib</code>	Deprecated: Manipulate MH mailboxes from Python.
<code>mimetools</code>	Deprecated: Tools for parsing MIME-style message bodies.
<code>mimetypes</code>	Mapping of filename extensions to MIME types.
<code>MimeWriter</code>	Deprecated: Write MIME format files.
<code>mimify</code>	Deprecated: Mimification and unmimification of mail messages.
<code>MiniAEFrame (Mac)</code>	Support to act as an Open Scripting Architecture (OSA) server ("Apple Events").
<code>mmap</code>	Interface to memory-mapped files for Unix and Windows.
<code>modulefinder</code>	Used to generate a module dependency graph.
<code>msilib (Windows)</code>	Creation of Microsoft Installer files, and CAB files.
<code>msvcrt (Windows)</code>	Module to use routines from the MS VC++ runtime.
<code>multifile</code>	Deprecated: Support for reading files which contain distinct parts, such as some MIME data.
+ multiprocessing	Process-based "threading" interface.
<code>mutex</code>	Deprecated: Lock and queue for mutual exclusion.
N	
<code>Nav (Mac)</code>	Deprecated: Interface to Navigation Services.
<code>netrc</code>	Loading of <code>.netrc</code> files.
<code>new</code>	Deprecated: Interface to the creation of runtime implementation objects.
<code>nis (Unix)</code>	Interface to Sun's NIS (Yellow Pages) library.
<code>nnplib</code>	NNTP protocol client (requires sockets).
<code>numbers</code>	Numeric abstract base classes (<code>Complex</code> , <code>Real</code> , <code>Integral</code> , etc.).
O	
<code>operator</code>	Functions corresponding to the standard operators.

dozens of built-in modules!



<http://xkcd.com/353/>

Making a Script Executable

When a script/module is run from the command line, a special variable called `__name__` is set to "`__main__`"

```
# all your module stuff here

# at the bottom stick...
if __name__ == "__main__":
    """only executed if this module is called from the command line"""
    print "I was called from the command line!"
```

On the first line of a script, say what to run the script with (as with Perl or shell scripts):

```
#!/usr/bin/env python
"""doctring for this module"""
# all your module stuff here
```

set execute permissions of that script

```
BootCamp> chmod a+x script_name.py  ## this works in UNIX, Mac OSX
BootCamp> ./script_name.py
I was called from the command line!
```

```
#!/usr/bin/env python
"""
Some functions written to demonstrate a bunch of concepts like modules, import
and command-line programming
"""
import os
import sys

def getinfo(path=".", show_version=True):
    """
    Purpose: make simple use of os and sys modules
    Input: path (default = "."), the directory you want to list
    """
    if show_version:
        print "-" * 40
        print "You are using Python version ",
        print sys.version
        print "-" * 40

    print "Files in the directory " + str(os.path.abspath(path)) + ":"
    for f in os.listdir(path): print "  " + f
    print "*" * 40

if __name__ == "__main__":
    """
    Executed only if run from the command line.
    call with modfun.py <dirname> <dirname> ...
    If no dirname is given then list the files in the current path
    """
    if len(sys.argv) == 1:
        getinfo(".", show_version=True)
    else:
        for i, dir in enumerate(sys.argv[1:]):
            if os.path.isdir(dir):
                # if we have a directory then operate on it
                # only show the version info if it's the first directory
                getinfo(dir, show_version=(i==0))
            else:
                print "Directory: " + str(dir) + " does not exist."
                print "*" * 40
```

file: modfun.py

```
BootCamp> ./modfun.py
```

```
-----  
You are using Python version  2.7.2 |EPD 7.2-2 (32-bit)| (r265:79063, Jan 11 2012, 15:13:03)  
[GCC 4.0.1 (Apple Inc. build 5488)]  
-----
```

```
Files in the directory /Users/jbloom/Classes/BootCamp:
```

```
basic training.key  
data structures.key  
modfun.html  
modfun.py  
modfun.pyc
```

```
...
```

```
*****
```

```
BootCamp> ./modfun.py . MySpamDir /tmp/
```

```
-----  
You are using Python version  2.7.2 |EPD 6.2-2 (32-bit)| (r265:79063, Jan 11 2012, 15:13:03)  
[GCC 4.0.1 (Apple Inc. build 5488)]  
-----
```

```
Files in the directory /Users/jbloom/Classes/BootCamp:
```

```
basic training.key  
data structures.key  
modfun.html  
modfun.py  
modfun.pyc  
modfun.py~  
modules_def_io.key
```

```
...
```

```
*****
```

```
Directory: MySpamDir does not exist.
```

```
*****
```

```
Files in the directory /tmp:
```

```
.font-unix  
.ICE-unix  
.X0-lock  
.X11-unix  
dao.param
```

```
...
```

```
*****
```

```
BootCamp>
```


If you make changes to a (module) file and want to reload it into the name space:

`reload(module_name)`

this is also true if you want to reload a module that was imported from an (unchanged) module

```
>>> import os ; os.system("cat josh1.py josh2.py")
# josh1.py
import josh2
x = 1
# josh2.py
y = 2
>>> import josh1 ; print josh1.josh2.y
2
>>> ### now edit josh2
>>> os.system("cat josh1.py josh2.py")
import josh2
x = 1
# josh2.py
y = True
>>> reload(josh1.josh2) ; print josh1.josh2.y
True
```

Breakout Session

exploring some modules

remember: `help()`

A. create and edit a new file called **age.py**

B. within **age.py**, import the **datetime** module

- use `datetime.datetime()` to create a variable representing when you were born
- use `datetime.datetime.now()` to create a variable representing now
- subtract the two, forming a new variable, which will be a `datetime.timedelta()` object. Print that variable.

1. how many days have you been alive? How many hours?

2. What will be the date in 1000 days from now?

C. create and edit a new file called **age1.py**

when run from the command line with 1 argument, `age1.py` should print out the date in days from now. If run with three arguments print the time in days since then

```
BootCamp> ./age1.py 1000
date in 1000 days 2014-10-09 07:40:49.682973
BootCamp> ./age1.py 1980 1 8
days since then... 11699
```