Python for data science

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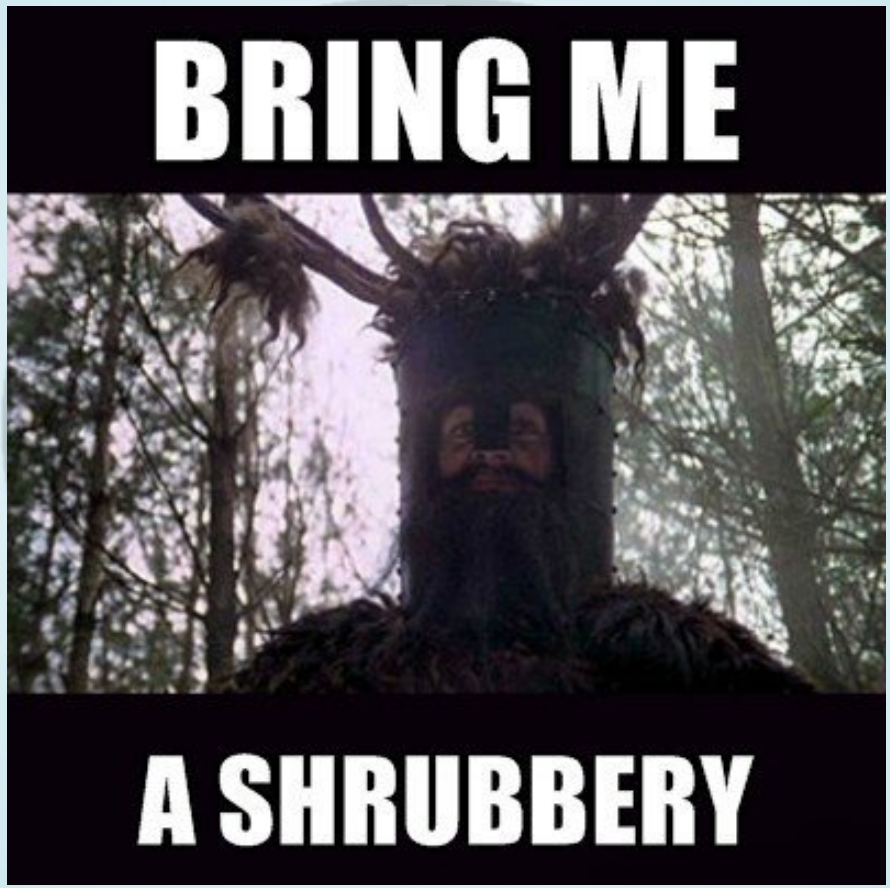
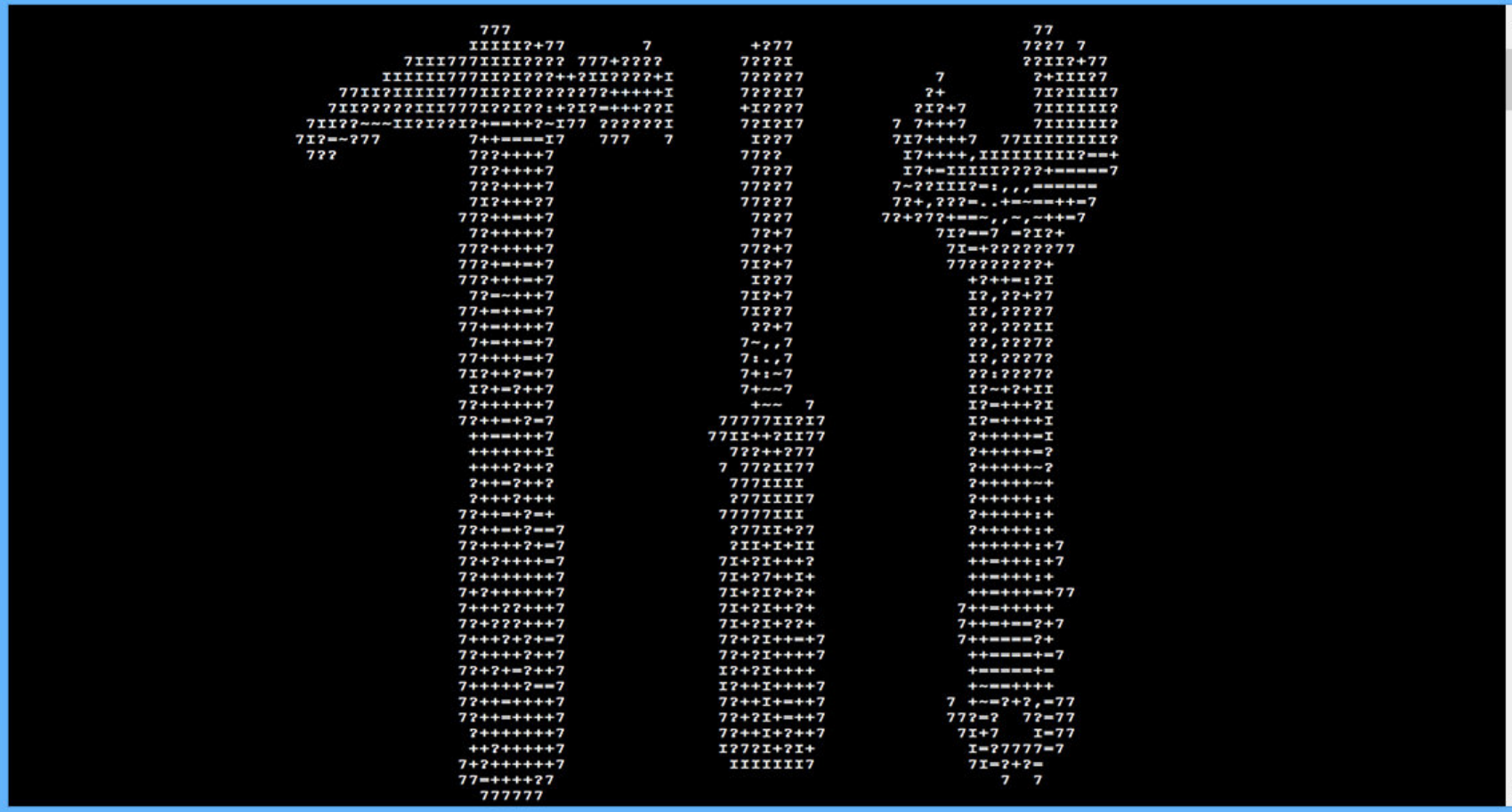


We are the Knights who say ni!

COMMAND LINE



Where is the command line?

Windows

Search for cmd

Mac OS X

The Mac command line is a program called Terminal. It lives in the folder

`/Applications/Utilities/`

Linux

You already know the answer

Go to the command line

```
Microsoft Windows [Version 10.0.10586]
(c) 2015 Microsoft Corporation. All rights reserved.

C:\Users\jajaco3>
```

The letter may be different...so you might see something like:

```
D:\YourName\Projects\Python>
```

From now on we will denote the command line by a dollar sign.

```
$
```

Command syntax

Windows	Mac OS X	Linux
dir	ls	ls
cd	cd	cd
cd..	cd ..	cd ..
cd\	cd\	cd\
mkdir	mkdir	mkdir
rmdir	rm	rm

```
$ conda

usage: conda-script.py [-h] [-V] [--debug] command ...

conda is a tool for managing and deploying applications, environments and packages.

Options:

positional arguments:
  command
    info         Display information about current conda install.
```

```
$ conda info
Current conda install:

            platform : win-64
       conda version : 4.1.6
    conda-env version : 2.5.1
  conda-build version : 1.21.3
       python version : 2.7.12.final.0
     requests version : 2.10.0
     root environment : C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2  (writable)
  default environment : C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2
     envs directories : C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2\envs
        package cache : C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2\pkgs
         channel URLs : https://repo.continuum.io/pkgs/free/win-64/
                        https://repo.continuum.io/pkgs/free/noarch/
                        https://repo.continuum.io/pkgs/pro/win-64/
                        https://repo.continuum.io/pkgs/pro/noarch/
          config file : None
        offline mode : False
    is foreign system : False
```

What if I need to reproduce someone elses calculation using specific versions of various packages?

```
$ conda create --name reproduceEnv python=2.7 bokeh=0.12.3

Fetching package metadata .......
Solving package specifications: ..........

Package plan for installation in environment C:\Users\jajaco3\AppData\Local\Continuum\Anaconda

The following NEW packages will be INSTALLED:

    backports:          1.0-py27_0
    backports_abc:      0.4-py27_0
    bokeh:              0.12.3-py27_1
    futures:            3.0.5-py27_0
    jinja2:             2.8-py27_1
    markupsafe:         0.23-py27_2
    mkl:                11.3.3-1
    numpy:              1.11.2-py27_0
    pip:                8.1.2-py27_0
    python:             2.7.12-0
    python-dateutil:    2.5.3-py27_0
    pyyaml:             3.12-py27_0
    requests:           2.11.1-py27_0
    setuptools:         27.2.0-py27_1
    singledispatch:     3.4.0.3-py27_0
    six:                1.10.0-py27_0
    ssl_match_hostname: 3.4.0.2-py27_1
    tornado:            4.4.2-py27_0
    vs2008_runtime:     9.00.30729.1-2
    wheel:              0.29.0-py27_0

Proceed ([y]/n)?
```

If you were to hit 'y' you would see this:

```
Fetching packages ...
numpy-1.11.2-p 100% |################################| Time: 0:00:00   7.95 MB/s
pyyaml-3.12-py 100% |################################| Time: 0:00:00   1.10 MB/s
requests-2.11. 100% |################################| Time: 0:00:00   3.06 MB/s
setuptools-27. 100% |################################| Time: 0:00:00   3.83 MB/s
tornado-4.4.2- 100% |################################| Time: 0:00:00   2.69 MB/s
bokeh-0.12.3-p 100% |################################| Time: 0:00:00   5.53 MB/s
Extracting packages ...
[      COMPLETE      ]|##################################################| 100%
Linking packages ...
[      COMPLETE      ]|##################################################| 100%
#
# To activate this environment, use:
# > activate reproduceEnv
#
# To deactivate this environment, use:
# > deactivate
#

$
```

To verify that the 'reproduceEnv' environment has now been added, type the command:

```
$ conda info --envs

# conda environments:
#
reproduceEnv             C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2\envs\reproduceEnv
root                  *  C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2
```

Activate this environment with:

MAC/LINUX:

```
$ source activate reproduceEnv
```

WINDOWS:

```
C:\>activate reproduceEnv

(reproduceEnv) C:\>
```

Verify the correct versions with:

```
(reproduceEnv) C:\>python --version
Python 2.7.12 :: Continuum Analytics, Inc.

(reproduceEnv) C:\>bokeh --version
0.12.3

(reproduceEnv) C:\>
```

To return to Anaconda installed defaults, deactivate this environment with the command:

MAC/LINUX:

```
$ source deactivate reproduceEnv
```

WINDOWS:

```
(reproduceEnv) C:\>deactivate reproduceEnv

 C:\>
```

Verify the Anaconda installed default version with:

```
C:\>python --version
Python 2.7.12 :: Anaconda 4.1.1 (64-bit)

C:\>bokeh --version
0.12.0

C:\>
```

To list packages available use:

```
$ conda list
# packages in environment at C:\Users\jajaco3\AppData\Local\Continuum\Anaconda2:
#
_nb_ext_conf              0.2.0                    py27_0
alabaster                 0.7.8                    py27_0
anaconda                  4.1.1                np111py27_0
anaconda-client           1.4.0                    py27_0
anaconda-navigator        1.2.1                    py27_0
argcomplete               1.0.0                    py27_1
astropy                   1.2.1                np111py27_0
babel                     2.3.3                    py27_0
backports                 1.0                      py27_0
backports_abc             0.4                      py27_0
beautifulsoup4            4.4.1                    py27_0
bitarray                  0.8.1                    py27_1
blaze                     0.10.1                   py27_0
bokeh                     0.12.0                   py27_0
boto                      2.40.0                   py27_0
bottleneck                1.1.0                np111py27_0
bzip2                     1.0.6                     vc9_3  [vc9]
cdecimal                  2.3                      py27_2
cffi                      1.6.0                    py27_0
chest                     0.2.3                    py27_0
click                     6.6                      py27_0
cloudpickle               0.2.1                    py27_0
clyent                    1.2.2                    py27_0
colorama                  0.3.7                    py27_0
comtypes                  1.1.2                    py27_0
conda                     4.1.6                    py27_0
```

What is Python?

- Type commands individually into **interpreter**
- Create a **script** file (myPythonFile.py).

If you want to type commands individually, start the **Python interactive shell** by typing python.

```
$ python

Python 2.7.12 |Anaconda 4.1.1 (64-bit)| (default, Jun 29 2016, 11:07:13) [MSC v.1500 64 bit (A
Type "help", "copyright", "credits" or "license" for more information.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://anaconda.org

>>>
```

Python Interactive Shell

```
$ python

Python 2.7.12 |Anaconda 4.1.1 (64-bit)| (default, Jun 29 2016, 11:07:13) [MSC v.1500 64 bit (A
Type "help", "copyright", "credits" or "license" for more information.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://anaconda.org

>>>
```

```
>>> 2+2
4
>>> 53/3
17
>>> 53/4
13


>>> 53/4.0
13.25
>>> 53.0/4
13.25
```

The integer numbers (e.g. 2, 4, 20) have type: `int`

The decimals (e.g. 53.0, 4.0, 13.25) have type: `float`

If both operands are of type int, floor division is performed and an int is returned (e.g. 53/4 returns 13)

If either operand is a float, classic division is performed and a float is returned (e.g. 53.0/4 or 53/4.0 return 13.25)

```
>>> type(53/3)
<type 'int'>
>>> type(53)
<type 'int'>
>>> type(53.0)
<type 'float'>
```

comment

```
>>> 53 / 4 # int / int  -> int
13
>>> 53 / 4.0 # int / float -> float
13.25
>>> 53 // 4
13
>>> 53 // 4.0
13.0
>>> 53 // 4.0 # explicit floor division discards the remainder
13.0
>>> 53 % 4 # the % operator returns the remainder
1
>>> 13 * 4 + 1 # result * divisor + remainder
53
```

With Python, use the ** operator to calculate powers

```
>>> 9 ** 1
9
>>> 9 ** 2
81
>>> 9 ** 3
729
>>> 9 ** 4
6561
>>> 9 ** 5
59049
```

You can also use pow(,)

```
>>> pow(2,3)
8
>>> pow(9,1)
9
>>> pow(9,2)
81
>>> pow(9,3)
729
>>>
```

The equal sign (=) is used to assign a value to a variable. Afterwards, no result is displayed before the next cell.

```
>>> width = 23.56
>>> height = 46.9
>>>
```

If a variable is not “defined” (assigned a value), trying to use it will give you an error:

```
>>> heitgh * width
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'heitgh' is not defined
>>> height * width
1104.964
```

In interactive mode, the last printed expression is assigned to the variable _. This means that when you are using Python as a desk calculator, it is somewhat easier to continue calculations, for example:

```
>>> width = 23.5482934
>>> height = 46.923
>>> height * width
1104.9565712081999
>>> _
1104.9565712081999
>>> round(_,4)
1104.9566
>>> round(_,2)
1104.96
>>>
```

$$\binom{n}{k} = \frac{n!}{(n-k)!k!}$$

```
>>> factorial(10)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'factorial' is not defined


>>> math.factorial(10)
3628800
>>> math.factorial(2)*math.factorial(8)
80640
>>> math.factorial(10)/_
45
```

$$\binom{10}{2} = \frac{10!}{(10-2)!2!} = 45$$

$$\cos(\pi) = -1$$

```
>>> cos(pi)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'cos' is not defined
>>> math.cos(math.pi)
-1.0
```

$$10! = 3628800$$

$$\cos(\pi) = -1$$

```
>>> from math import cos, pi, factorial

>>> factorial(10)
3628800
>>> cos(pi)
-1.0
```

$$10! = 3628800$$

$$\cos(\pi) = -1$$

$$e^1 = 2.718281828459045090795598$$

```
>>> from math import *

>>> factorial(10)
3628800
>>> cos(pi)
-1.0
>>> exp(1)
2.718281828459045
```

$$e^1 = 2.718281828459045090795598298427648$$

```
>>> exp(1)
2.718281828459045


>>> format(exp(1), '.50g')
'2.7182818284590450907955982984276488423347473144531'

>>> format(exp(1), '.51g')
'2.71828182845904509079559829842764884233474731445312'

>>> format(exp(1), '.52g')
'2.718281828459045090795598298427648842334747314453125'

>>> format(exp(1), '.53g')
'2.718281828459045090795598298427648842334747314453125'
```

Python as a desktop calculator: fractions module

$$\frac{a}{b} + \frac{c}{d} = \frac{ad+bc}{bd}$$

$$\frac{a}{b} \times \frac{c}{d} = \frac{ac}{bd}$$

```
>>> from fractions import Fraction

>>> Fraction(1,6)
Fraction(1, 6)
>>> _
Fraction(1, 6)

>>> float(Fraction(1,6))
0.16666666666666666

>>> Fraction(1,6)+Fraction(1,6)
Fraction(1, 3)
```

$$\frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$$

$$\left(\frac{1}{6}\right)^2 = \frac{1}{36}$$

```
>>> Fraction(1,6)*Fraction(1,6)
Fraction(1, 36)
>>> Fraction(1,6)**2
Fraction(1, 36)
>>> pow(Fraction(1,6), 2)
0.027777777777777776
```

$$\left(\frac{1}{6}\right)^{15} = \frac{1}{470184984576}$$

```
>>> Fraction(1,6)**15
Fraction(1, 470184984576)
>>> float(_)
2.1268224907304786e-12
```

$$\frac{35}{19238} \times \frac{12}{12384} = \frac{35}{19853616}$$

```
>>> Fraction(35,19238)*Fraction(12,12384)
Fraction(35, 19853616)
>>>>>> float(_)
1.7629030399298546e-06
>>>
```

```
# Python 3: Fibonacci series up to n
>>> def fib(n):
>>>     a, b = 0, 1
>>>     while a < n:
>>>         print(a, end=' ')
>>>         a, b = b, a+b
>>>     print()
>>> fib(1000)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 98
```

```
# Python 3: Fibonacci series up to n
>>> def fib(n):
>>>     a, b = 0, 1
>>>     while a < n:
>>>         print(a, end=' ')
>>>         a, b = b, a+b
>>>     print()
>>> fib(1000)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 98
```

3 types of Functions

- functions always available for usage
- functions contained within external modules which must be imported
- functions defined by a programmer with the def keyword (see example on left).

Defining functions: Le Chevalier de Méré

$$P(\text{throw a pair of sixes}) = \frac{1}{36}$$

$$P(\text{do not throw a pair of sixes}) = \frac{35}{36}$$

$$P(\text{at least one pair of sixes in 24 throws}) = ?$$

$$= 1 - P(\text{no pair of sixes in 24 throws})$$

$$= 1 - \left(\frac{35}{36}\right)^{24}$$

Defining functions

$$P(\text{at least one pair of sixes in } n \text{ throws}) =$$
$$= 1 - \left(\frac{35}{36}\right)^n$$

```
>>> def chevalier(n):
...     return Fraction(1,1)-Fraction(35,36)**n
...
>>>
```

Defining functions

```
>>> chevalier(24)
Fraction(1103312646528397685291212796339228419 1, 22452257707354557240087211123792674816)
>>>
```

$$P(\text{at least one pair of sixes in 24 throws}) =$$

$$= \frac{1103312646528397685291212796339228419 1}{22452257707354557240087211123792674816}$$

Defining functions

```
>>> chevalier(24)
Fraction(1103312646528397685291212796339228419 1, 22452257707354557240087211123792674816)
>>> float(_)
0.49140387613090325
>>>
```

$$P(\text{at least one pair of sixes in 24 throws}) =$$

$$= \frac{1103312646528397685291212796339228419 1}{22452257707354557240087211123792674816}$$

$$= 0.49140387613090325$$

Defining functions

```
>>> chevalier(25)
Fraction(40861168399229374709201168984252262150 1, 8082812774647640606431396004565362933 76)
>>> float(_)
0.5055315462383781
>>>
```

$$P(\text{at least one pair of sixes in 25 throws}) =$$

$$= \frac{408611683992293747092011689842522621501}{808281277464764060643139600456536293376}$$

$$= 0.5055315462383781$$

Defining functions:

exit()

```
>>> exit()

C:\Users\jajaco3>python
Python 2.7.12 |Anaconda 4.1.1 (64-bit)| (default, Jun 29 2016, 11:07:13) [MSC v.1500 64 bit (A
Type "help", "copyright", "credits" or "license" for more information.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://anaconda.org
```

"Non défini!"

```
>>> chevalier(25)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'chevalier' is not defir
>>>
```

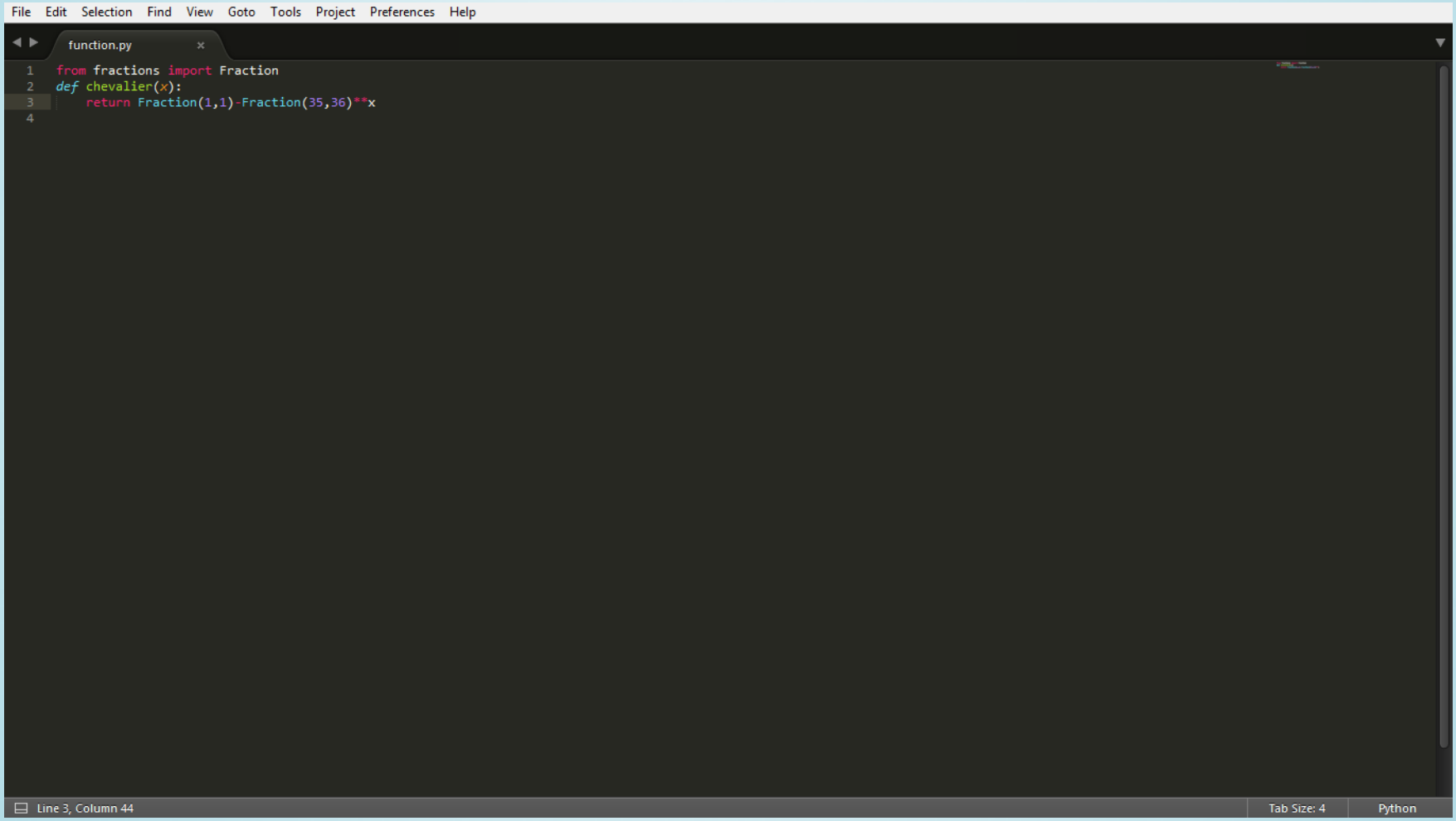
Writing Python code

If you want to reuse your function, you must write it down:

- In a .py file using a text editor, e.g. sublime text
- In a Ipython/Jupyter notebook

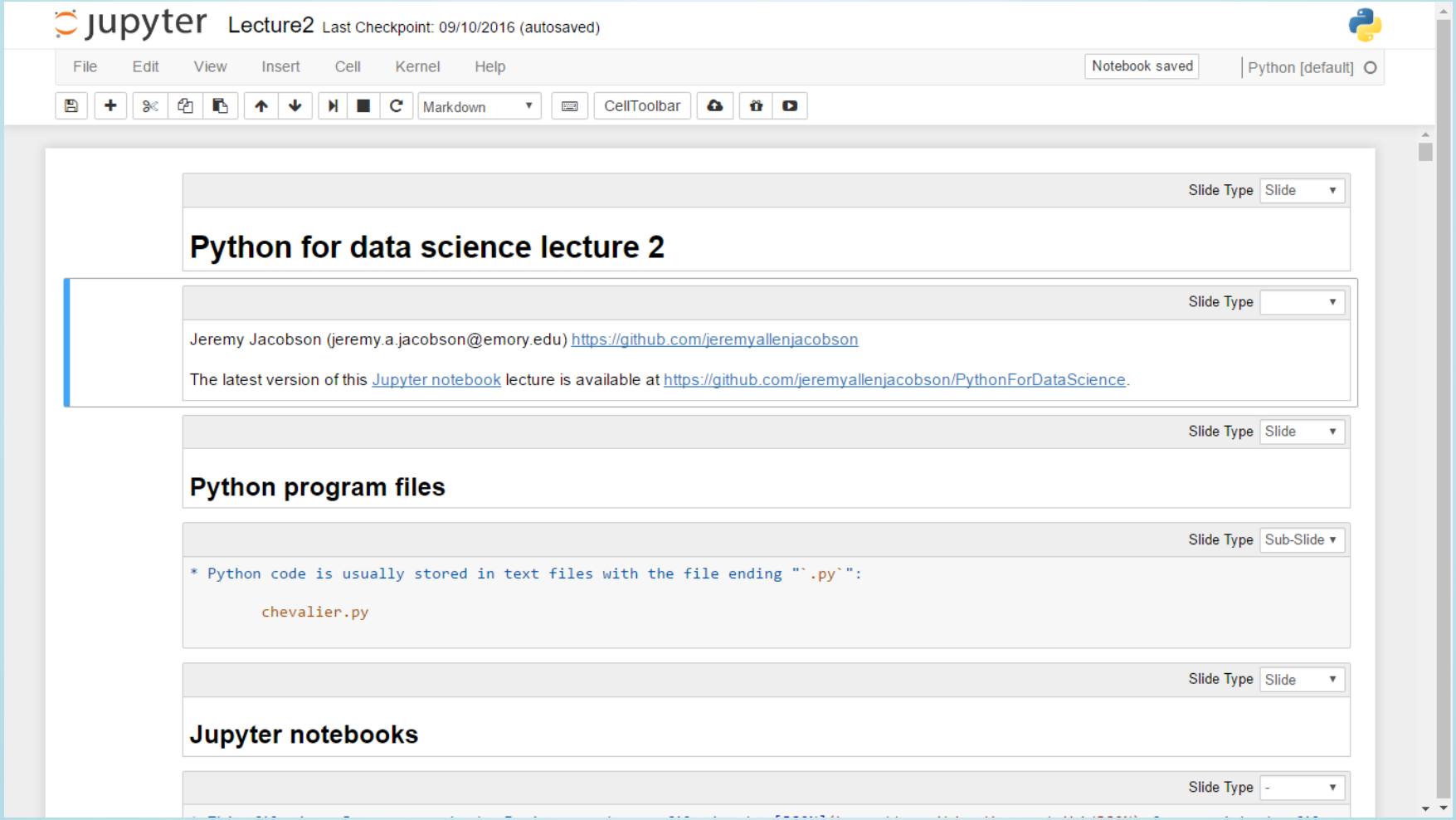
Writing Python code:

Sublime text



Writing Python code:

Jupyter Notebooks



Modules

- A module is a file containing Python definitions and statements.
- The file name is the module name with the suffix .py appended.
- For instance, use your favorite text editor to create a file called mymodule.py in the current directory with the following contents:

```
# Probability problem of Chevalier module
from fractions import Fraction
def chevalier(x):
        return Fraction(1,1)-Fraction(35,36)**x
def fchevalier(x):
        return float(Fraction(1,1)-Fraction(35,36)**x)
```

Modules

Now enter the Python interpreter and import this module with the following command:

```
C:\Users\jajaco3\Desktop\PythonForDataScience>python
Python 2.7.12 |Anaconda 4.1.1 (64-bit)| (default, Jun 29 2016, 11:07:13) [MSC v.1500 64 bit (A
Type "help", "copyright", "credits" or "license" for more information.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://anaconda.org
>>> import mymodule
```

Modules

Using the module name you can access the functions:

```
>>> mymodule.chevalier(24)
Fraction(1103312646528397685291212796339228419 1, 22452257707354557240087211123792674816)
>>> mymodule.fchevalier(24)
0.49140387613090325
>>>
```

Modules

If you intend to use a function often you can assign it to a local name:

```
>>> chev = mymodule.chevalier
>>> chev(25)
Fraction(4086116839922937470920116898425226215 01, 8082812774647640606431396004565362933 76)
>>> fchev = mymodule.fchevalier
>>> fchev(25)
0.5055315462383781
>>>
```

Modules

The built-in function dir() is used to find out which names a module defines.

It returns a sorted list of strings:

```
>>> import mymodule
>>> dir(mymodule)
['Fraction', '__builtins__', '__doc__', '__file__', '__name__', '__package__', 'chevalier', 'f
>>>
```

Modules

- The built-in function help() provides helpful information from "docstrings" written into the function.

```
>>> import math
>>> help(math.log)
Help on built-in function log in module math:

log(...)
    log(x[, base])

    Return the logarithm of x to the given base.
    If the base not specified, returns the natural logarithm (base e) of x.

>>>
```

- However, not all functions have docstrings (e.g. we did not write one for our function) but the vast majority are documented this way.

Modules:

packages

- Packages are a way of structuring Python's module namespace by using "dotted module names".
- For example, the module name A.B designates a submodule named B in a package named A.
- The use of dotted module names saves the authors of multi-module packages like NumPy from having to worry about each other's module names.

Modules:

Executing modules as script

- The code that parses the command line only runs if the module is executed as the “main” file

```
if __name__ == "__main__":
    import sys
    fchevalier(int(sys.argv[1]))
```