Python tutorial

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August 3, 2014

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Python's origin

- Guido Van Rossum (Netherlands)
- Created in 1991
- Named after Monty Python's flying circus

Python is a programming language

simple, powerful, fun

Python is a programming language

simple, powerful, fun

Python is mature yet in active development

Python Enhancement Proposals (PEP)

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Python Enhancement Proposals (PEP)

Python is a scripting language

- Dynamic typing
- Object oriented
- Interactive

Python is a programming language

simple, powerful, fun

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Python Enhancement Proposals (PEP)

Python is a scripting language

- Dynamic typing
- Object oriented
- Interactive

Python is cross-platform

Linux, Windows, Mac, android phones, ...

Python is glue

Easily interacts with

- filesystem, operating system
- command line tools
- compiled libraries (C, C++, Fortran)

Python is glue

Easily interacts with

- filesystem, operating system
- command line tools
- compiled libraries (C, C++, Fortran)

Python is a universe

- Batteries included
- Thousands of high-standard packages out there
- Open-source effort

Python is versatile

- Web Programming
- GUI Development
- Scientific and Numeric
- Software Development
- System Administration

Python happens to be suitable for science

- The “Scientific and Numeric” has been booming for 5 years
- Toolstack bundled as ’scipy’
  - Theano, numexpr, numba (Python math compilers)
  - Numpy (linear algebra)
  - Sympy (computer algebra system)
  - Pandas (data analysis)
  - Fenics, Fipy (Python for PDEs)
  - Vistrails (Python scientific workflow, data exploration and visualization)
  - matplotlib, chaco (2D plotting)
  - Mayavi (3D visualization)
  - Pyomo, cvxpy (Python optimization)

Python is a free and open-source ecosystem

- Tutorials, documentation
- Rapid bug-fixing
- Nightly testing (Continuous integration)
- Survival of the fittest

Python is popular

- Lingua Franca
- A huge user-base to ask/answer questions
- For every nail you want to hit, there might be 5 hammers out there

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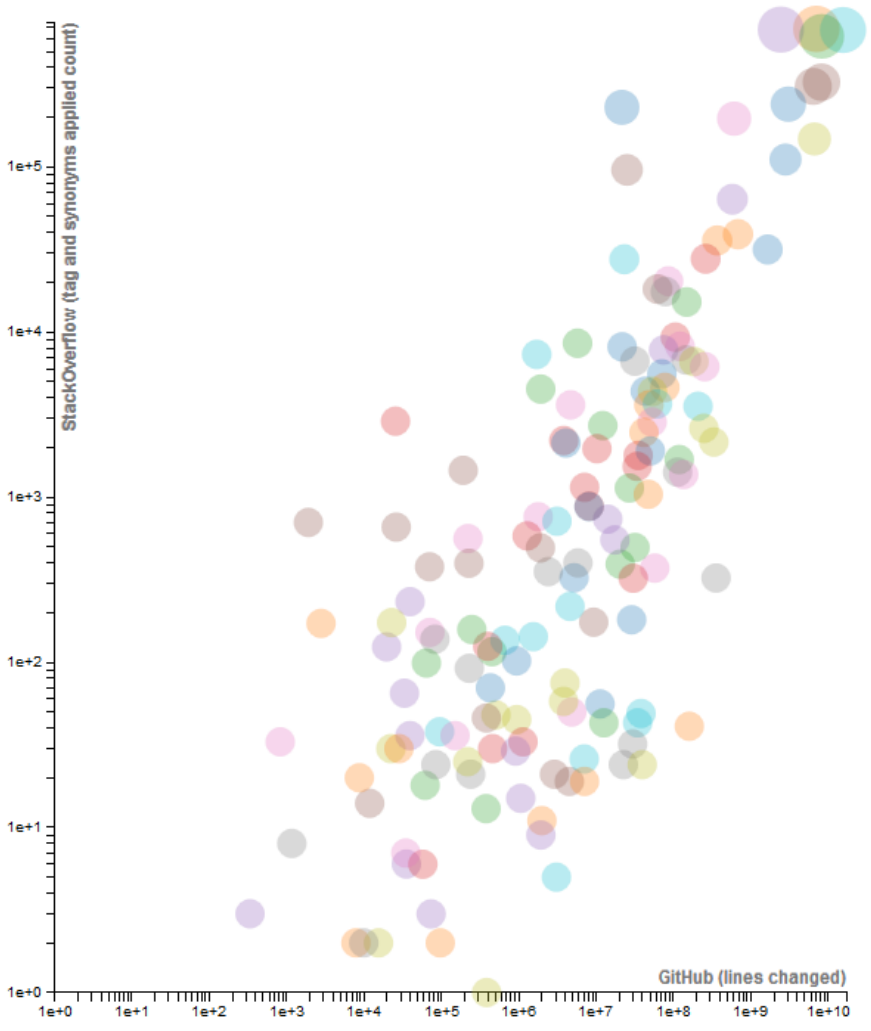

Java	C#	JavaScript
PHP	Python	C++
CSS	SQL	Objective-C
C	Ruby	XML
R	Perl	Matlab
Shell	Scala	Delphi
XSLT	PowerShell	Haskell
Assembly	Groovy	Awk
ActionScript	ColdFusion	Clojure
Cuda	Go	Lua
F#	CoffeeScript	Visual Basic
Erlang	Arduino	Prolog
Swift	Scheme	Dart
AppleScript	FORTRAN	Tcl
Max	SAS	Emacs Lisp
OCaml	TypeScript	Gnuplot
Racket	VHDL	XQuery
Processing	ANTLR	Common Lisp
D	Verilog	AspectJ
Puppet	Ada	Smalltalk
AutoHotkey	Pascal	AutoIt
Stata	Julia	Coq
Rust	HaXe	Vala
Self	Apex	Rebol
DOT	ABAP	COBOL
TeX	NetLogo	IDL

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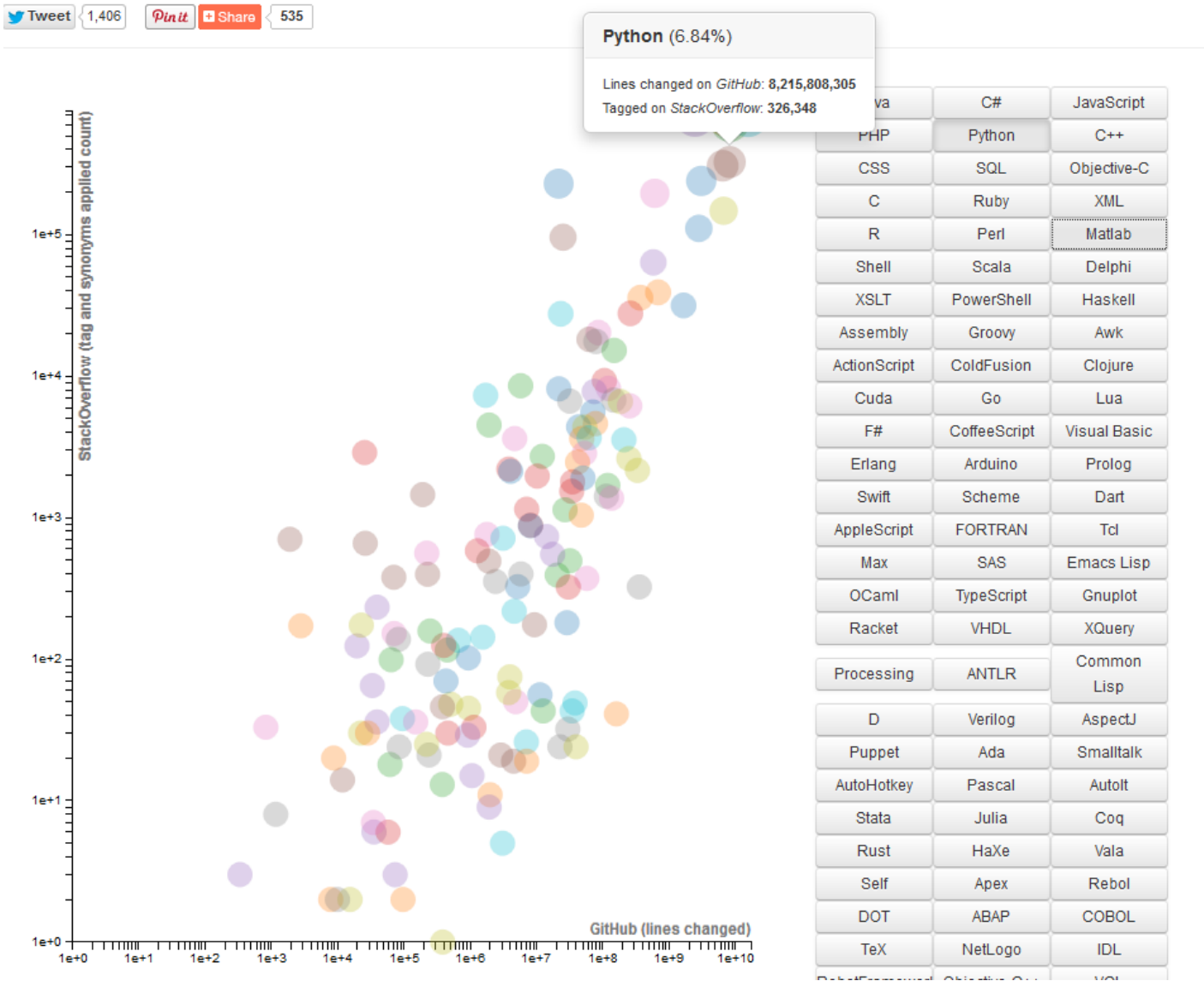

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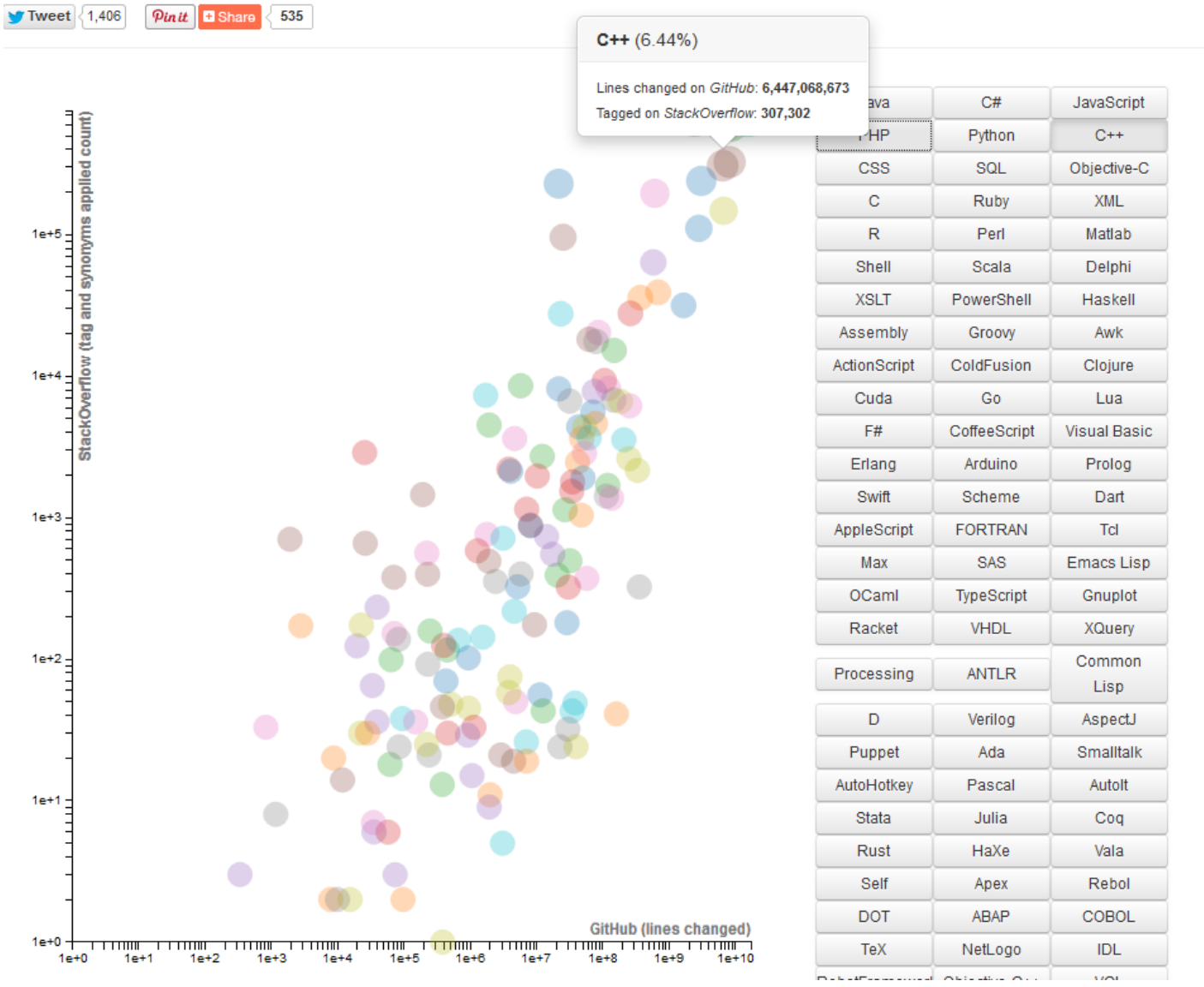

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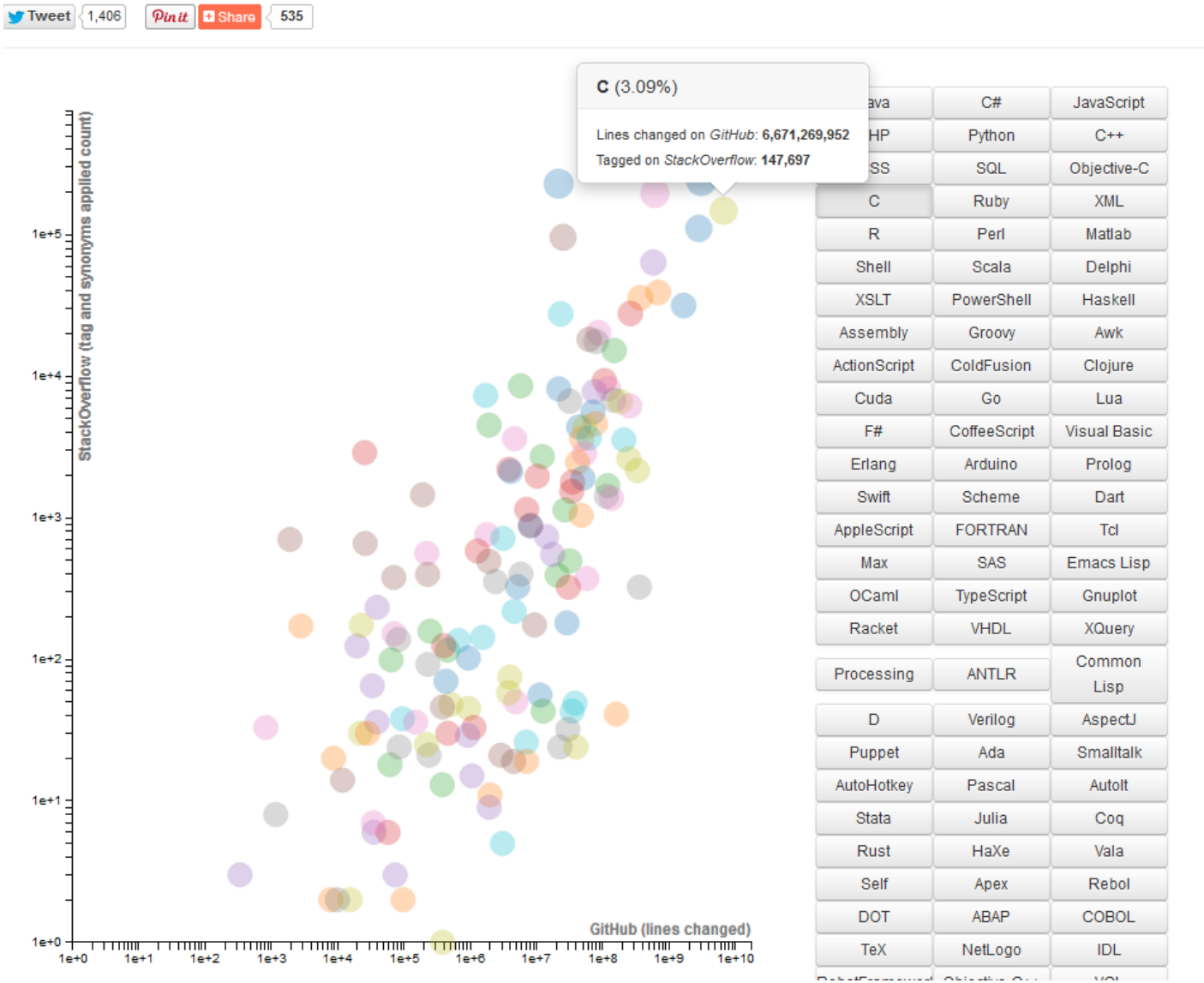

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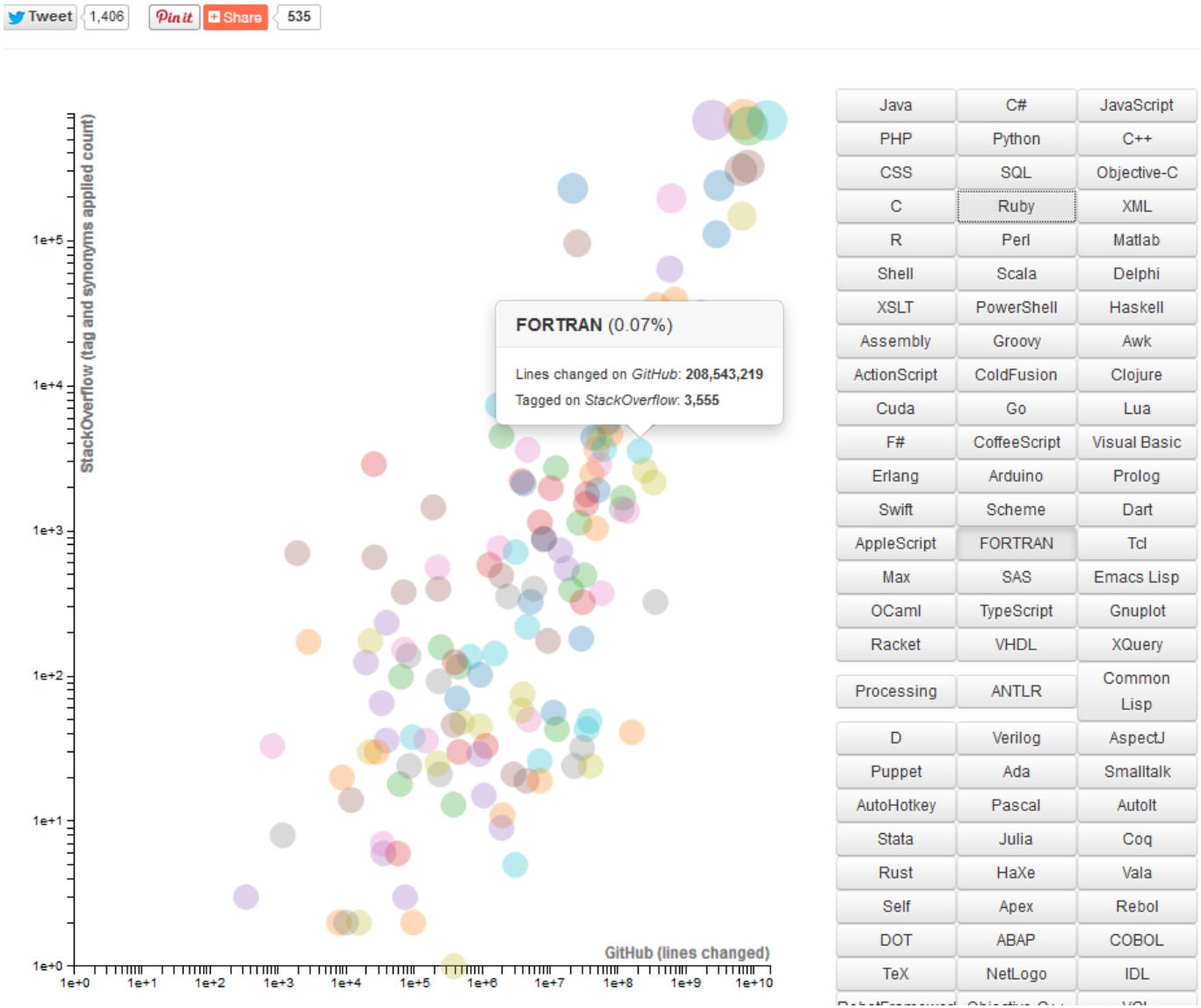

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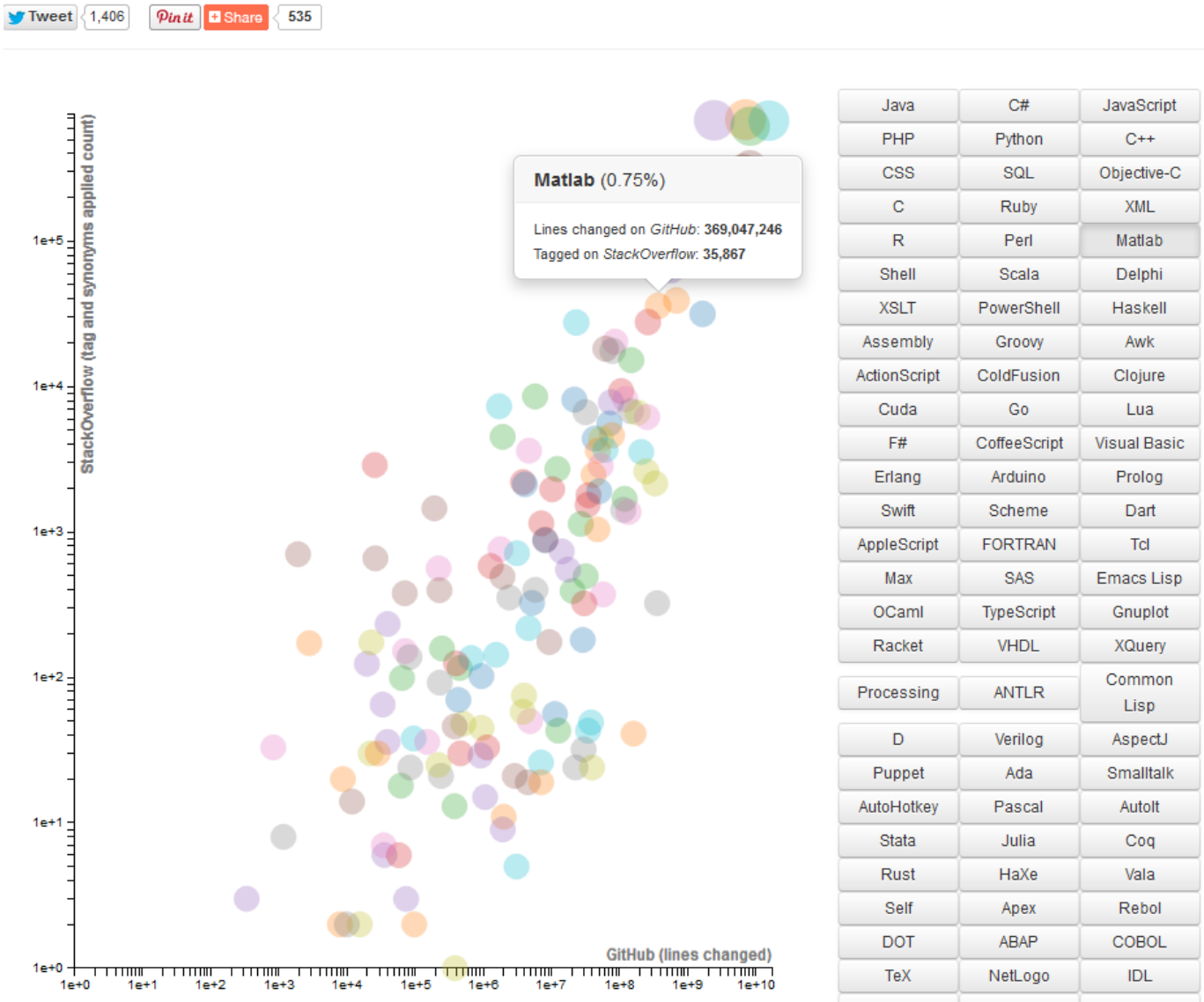

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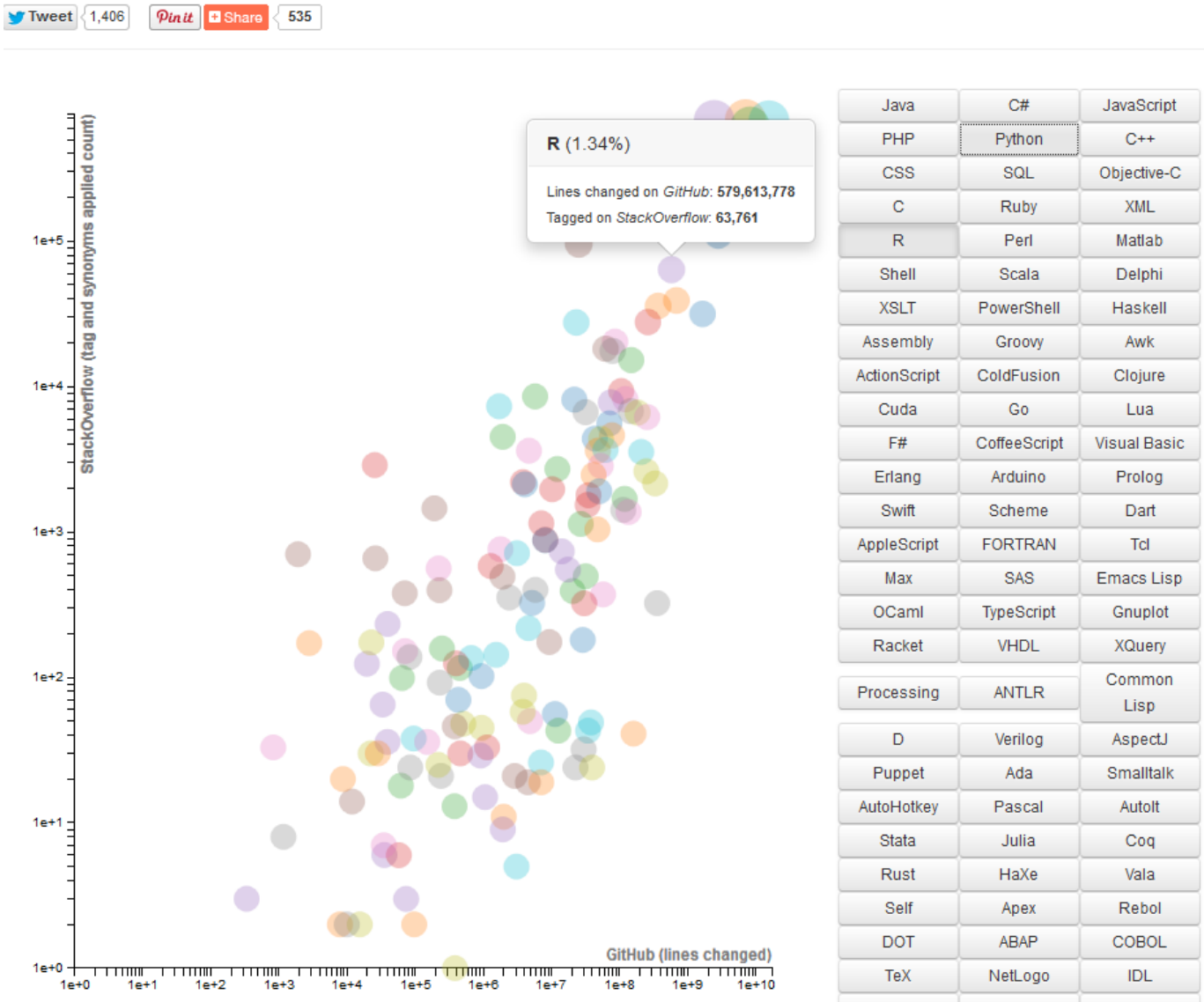

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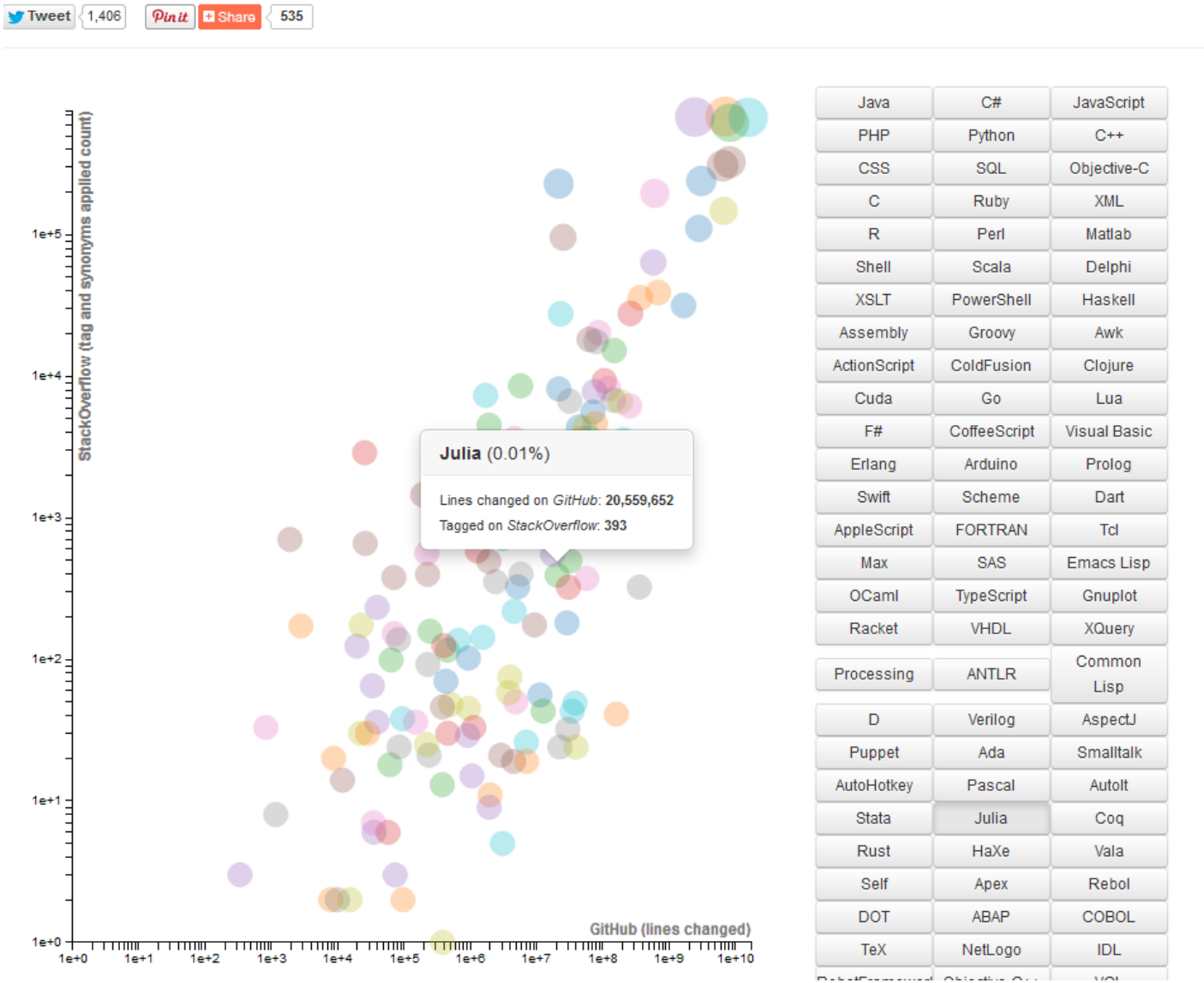

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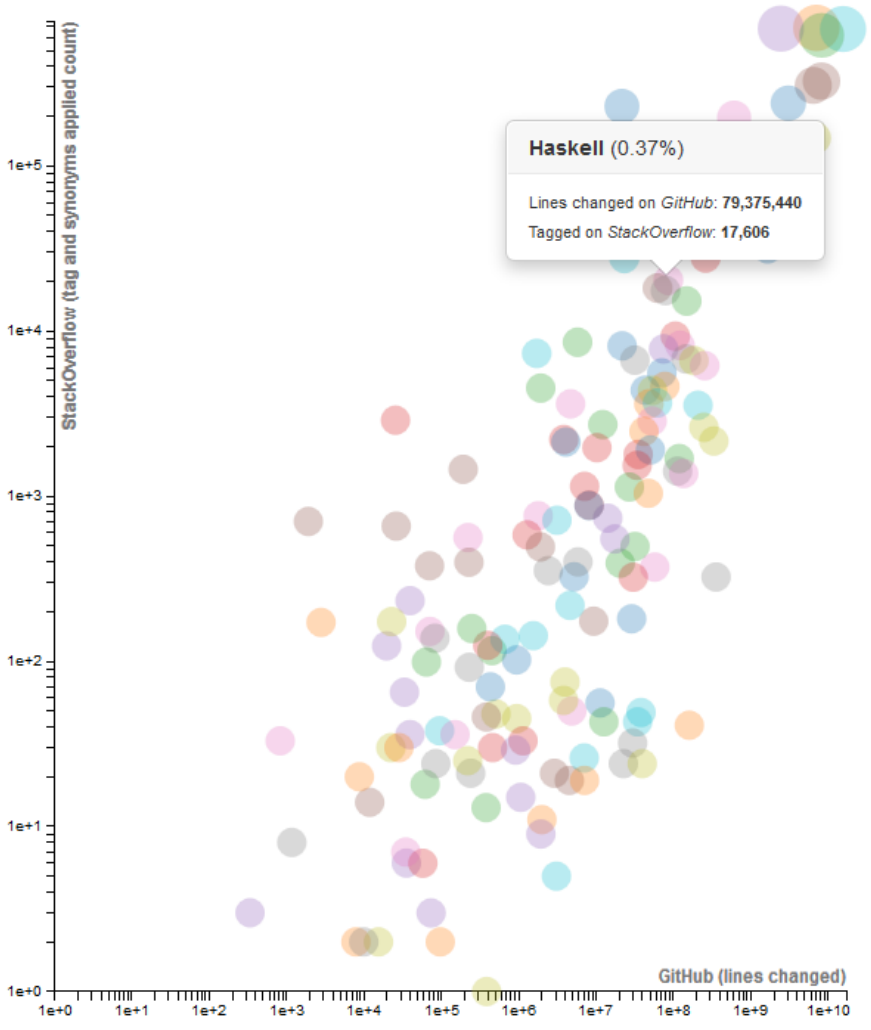

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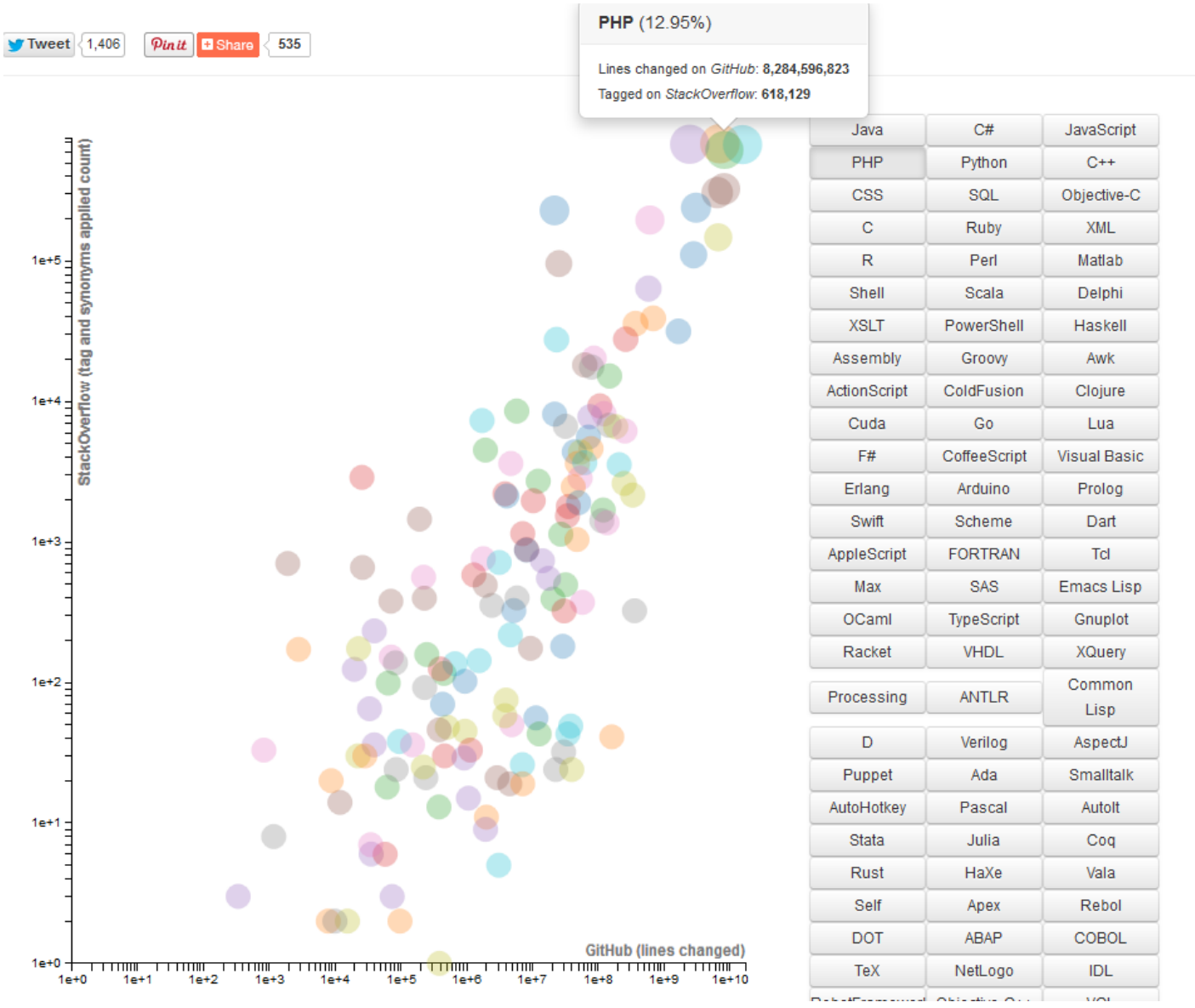

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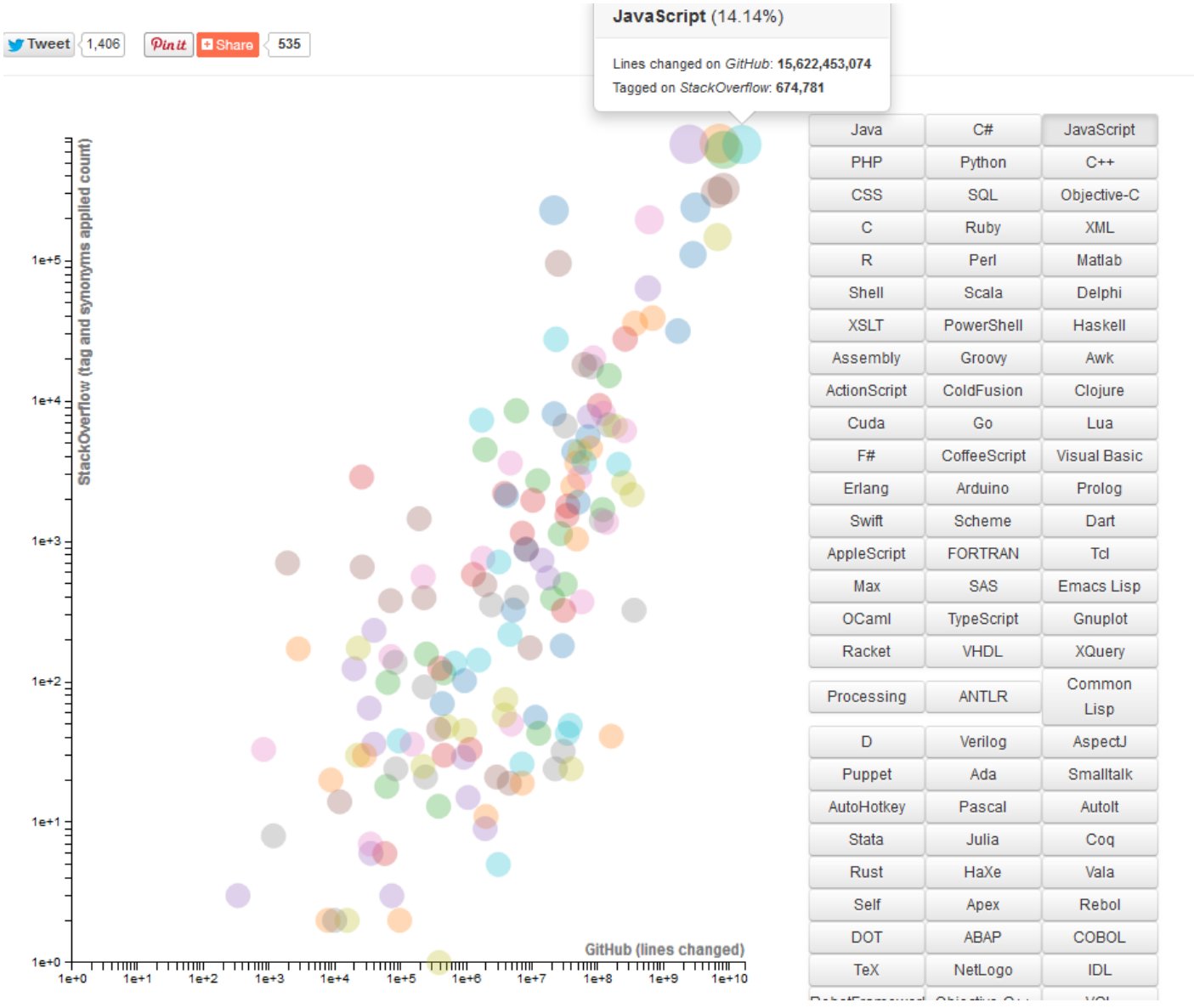
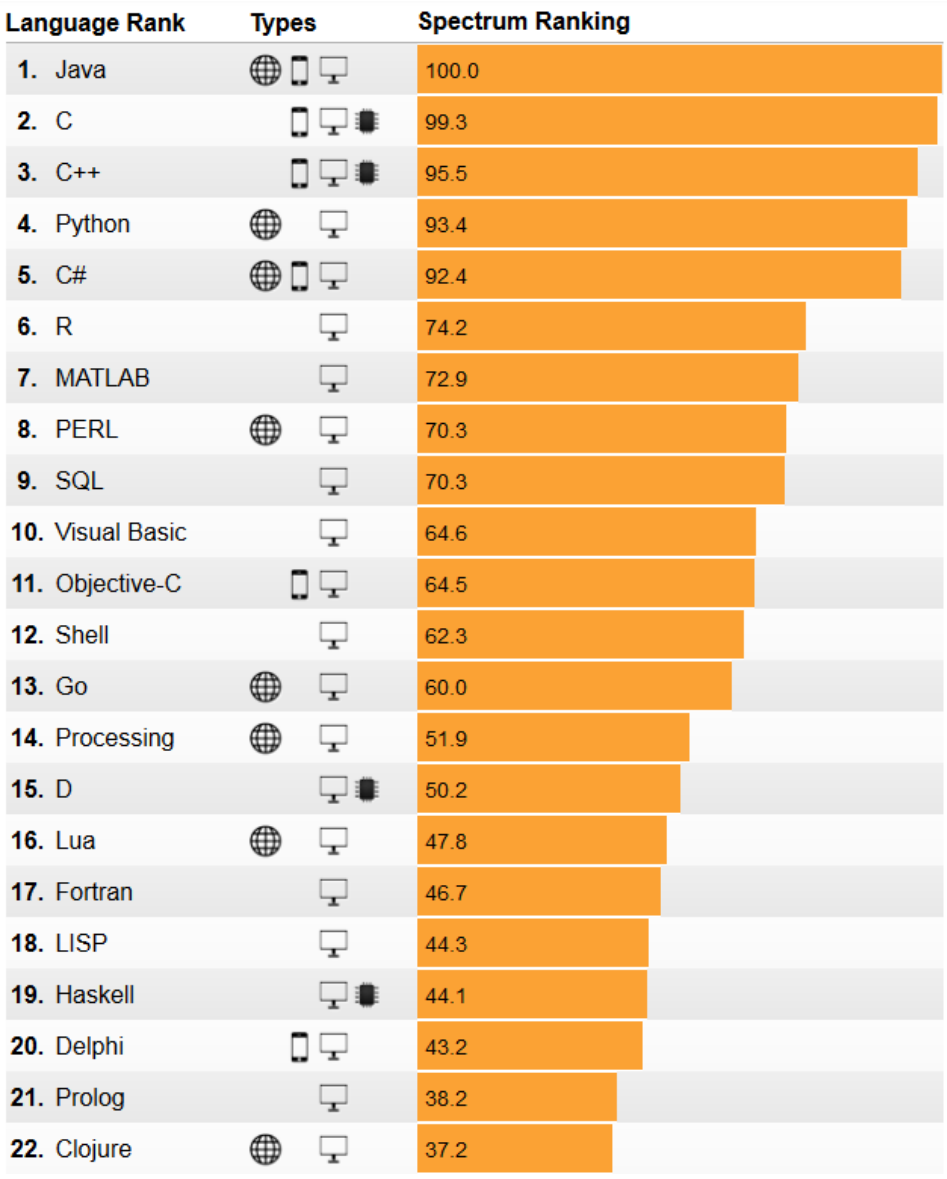


IEEE Spectrum's 2014 Ranking



Language Rank	Types	Spectrum Ranking
1. Java		100.0
2. C		99.3
3. C++		95.5
4. Python		93.4
5. C#		92.4
6. R		74.2
7. MATLAB		72.9
8. PERL		70.3
9. SQL		70.3
10. Visual Basic		64.6
11. Objective-C		64.5
12. Shell		62.3
13. Go		60.0
14. Processing		51.9
15. D		50.2
16. Lua		47.8
17. Fortran		46.7
18. LISP		44.3
19. Haskell		44.1
20. Delphi		43.2
21. Prolog		38.2
22. Clojure		37.2

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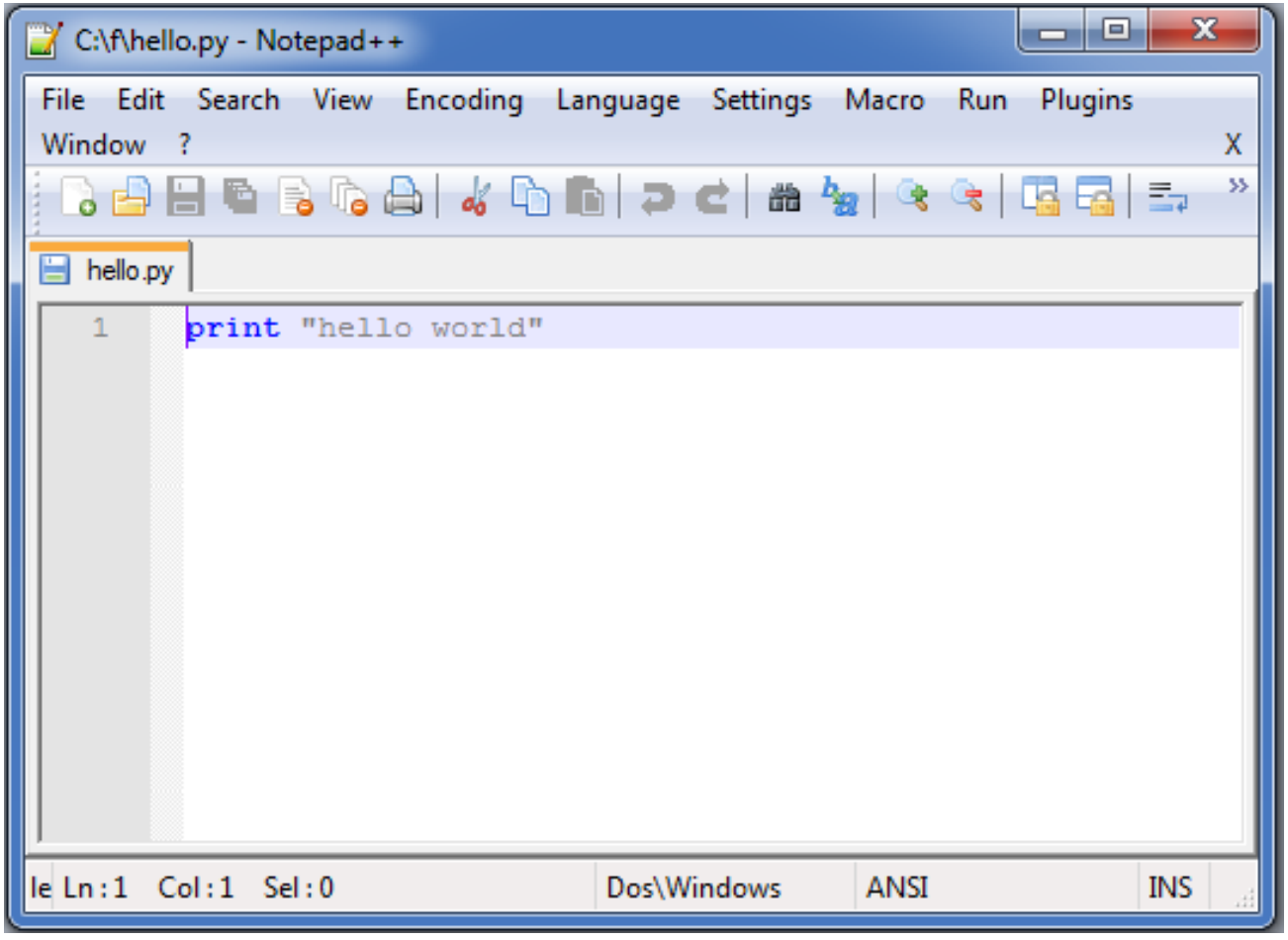
Option A: as command line argument

```
$ python -c "print 'hello world'"
```

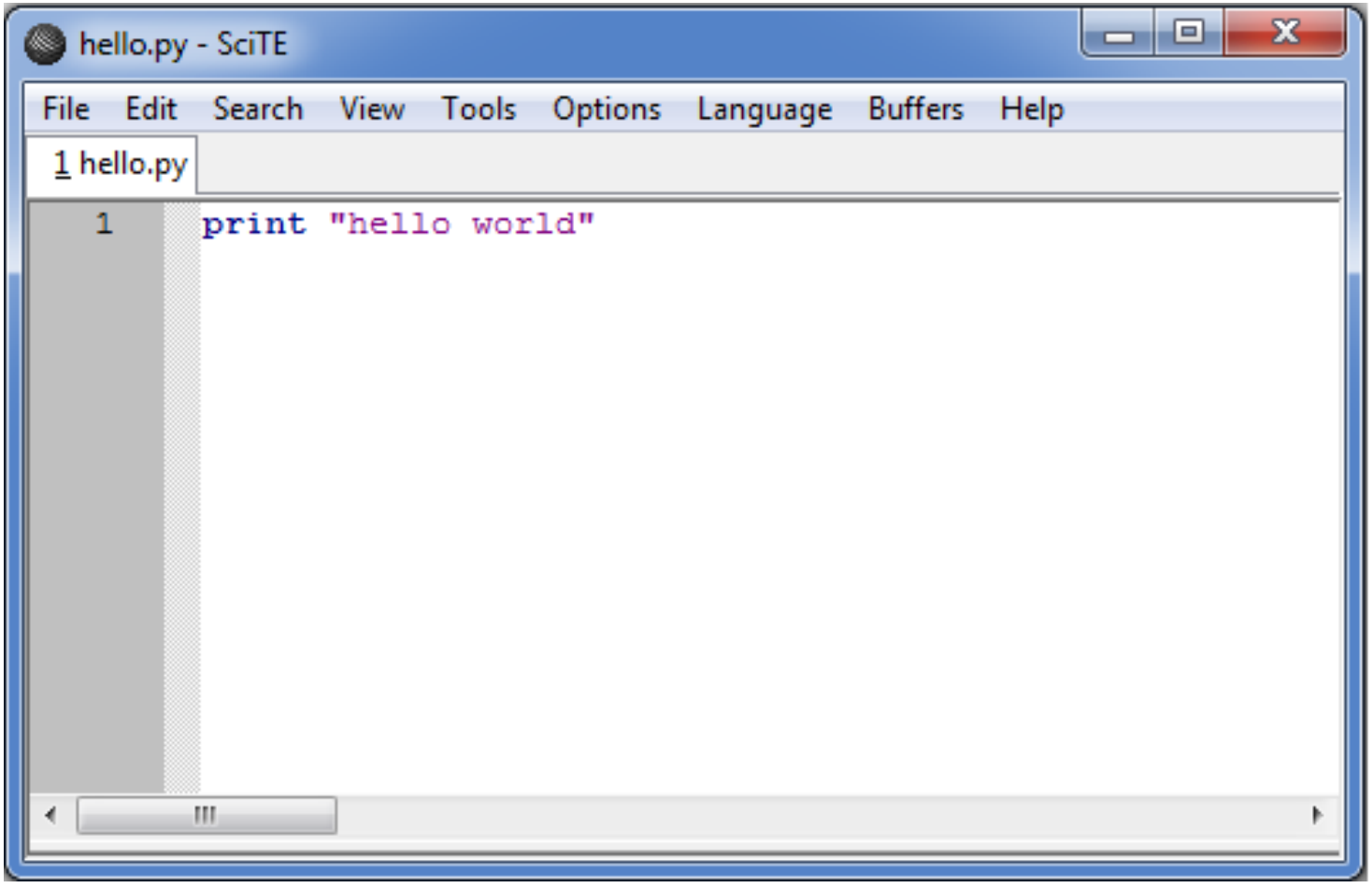
Option B: editor + command line invocation

Notepad++ (Windows)



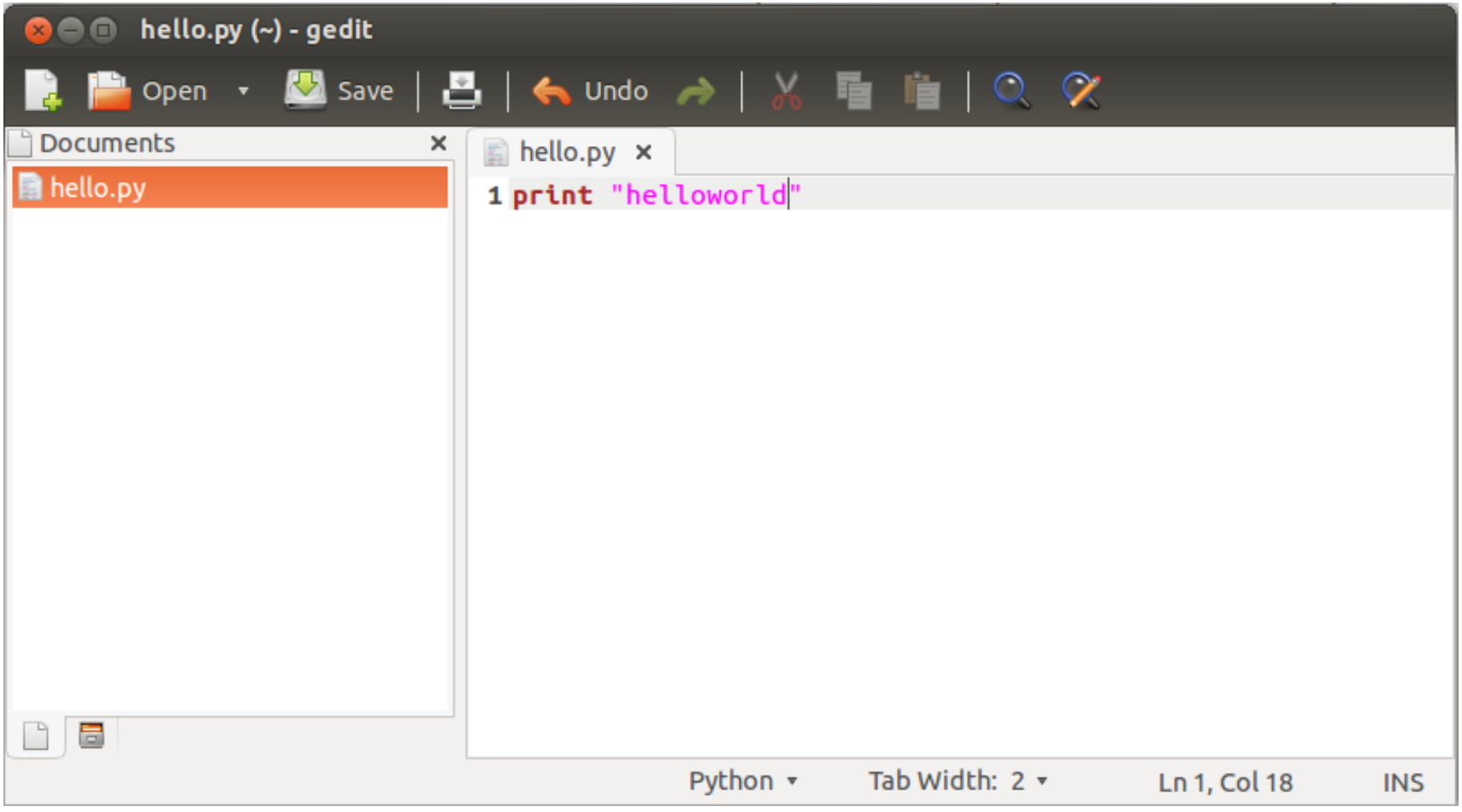
Option B: editor + command line invocation

Scite (Windows, Linux, Mac)



Option B: editor + command line invocation

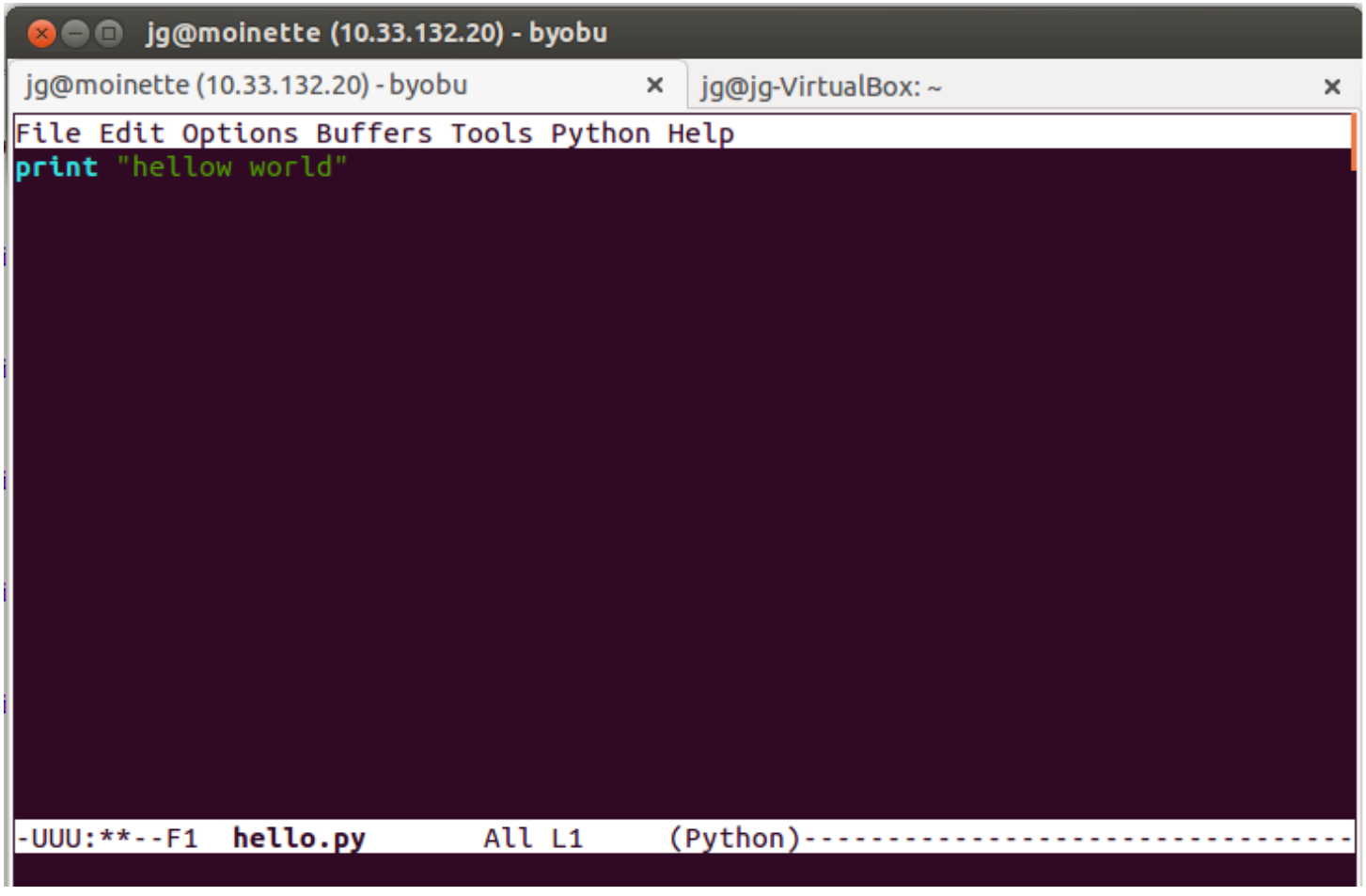
Gedit (Linux)



.

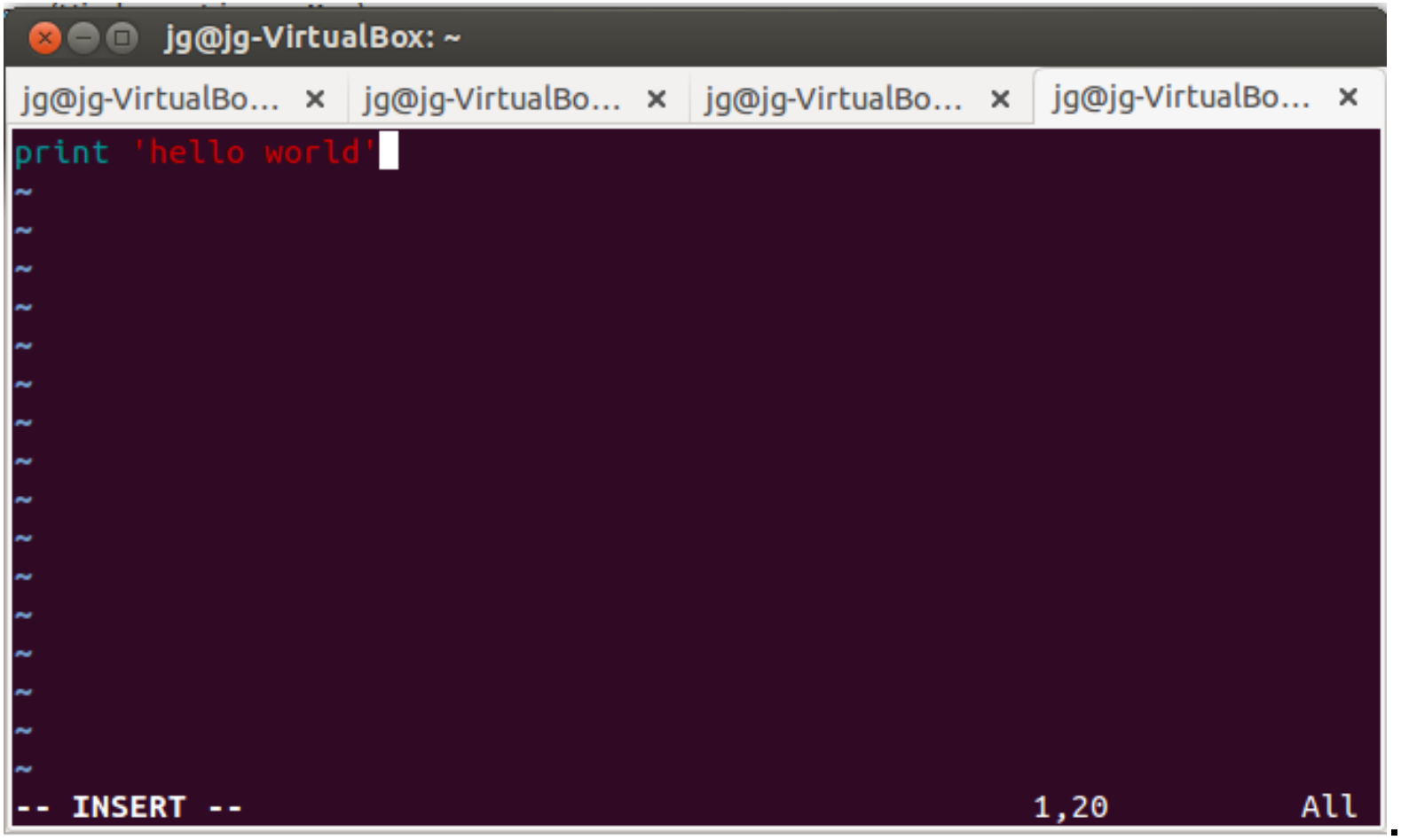
Option B: editor + command line invocation

Emacs (Windows, Linux, Mac)



Option B: editor + command line invocation

Vim (Windows, Linux, Mac)



Option B: editor + command line invocation

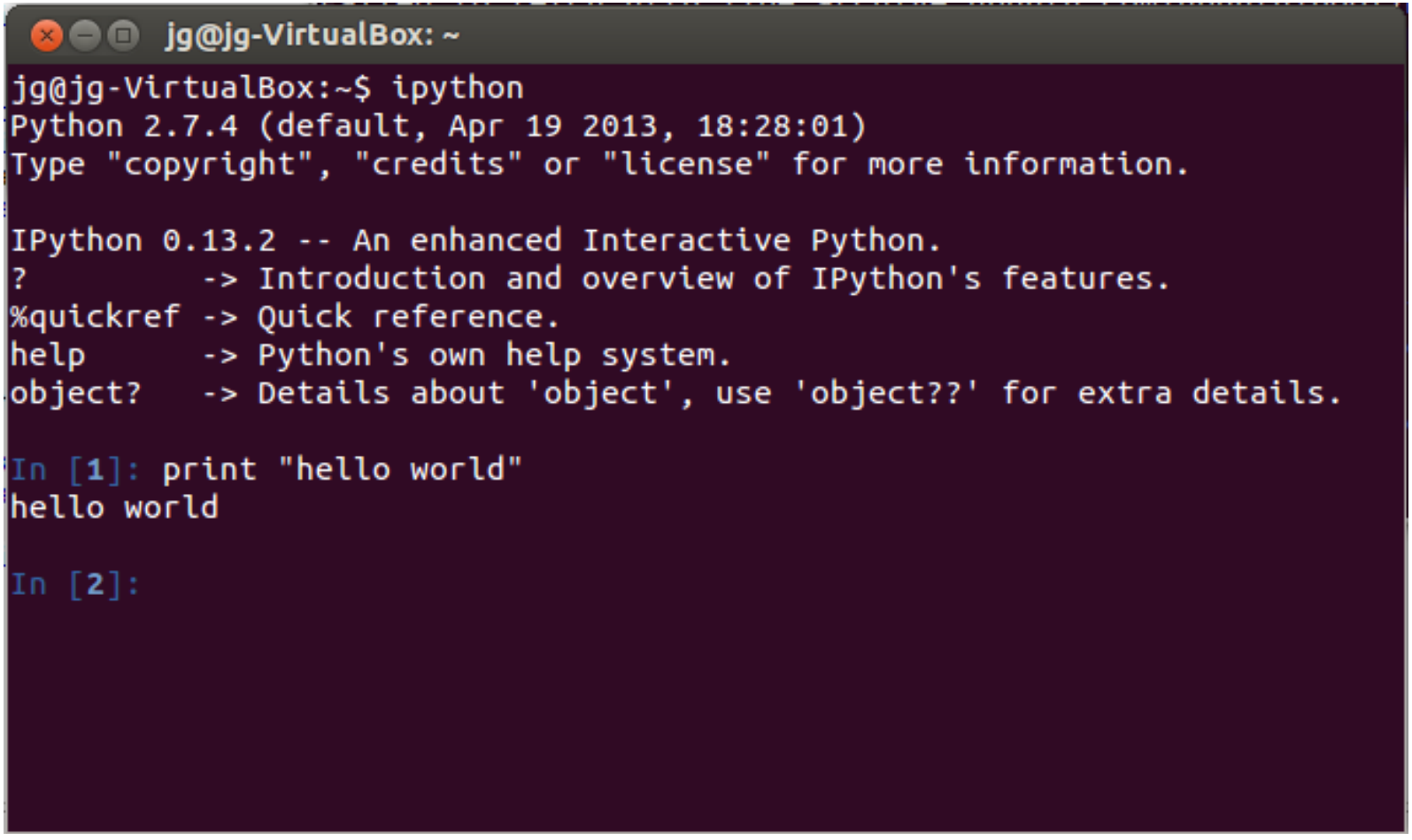
```
$ python hello.py
```

What you get

- Syntax highlighting

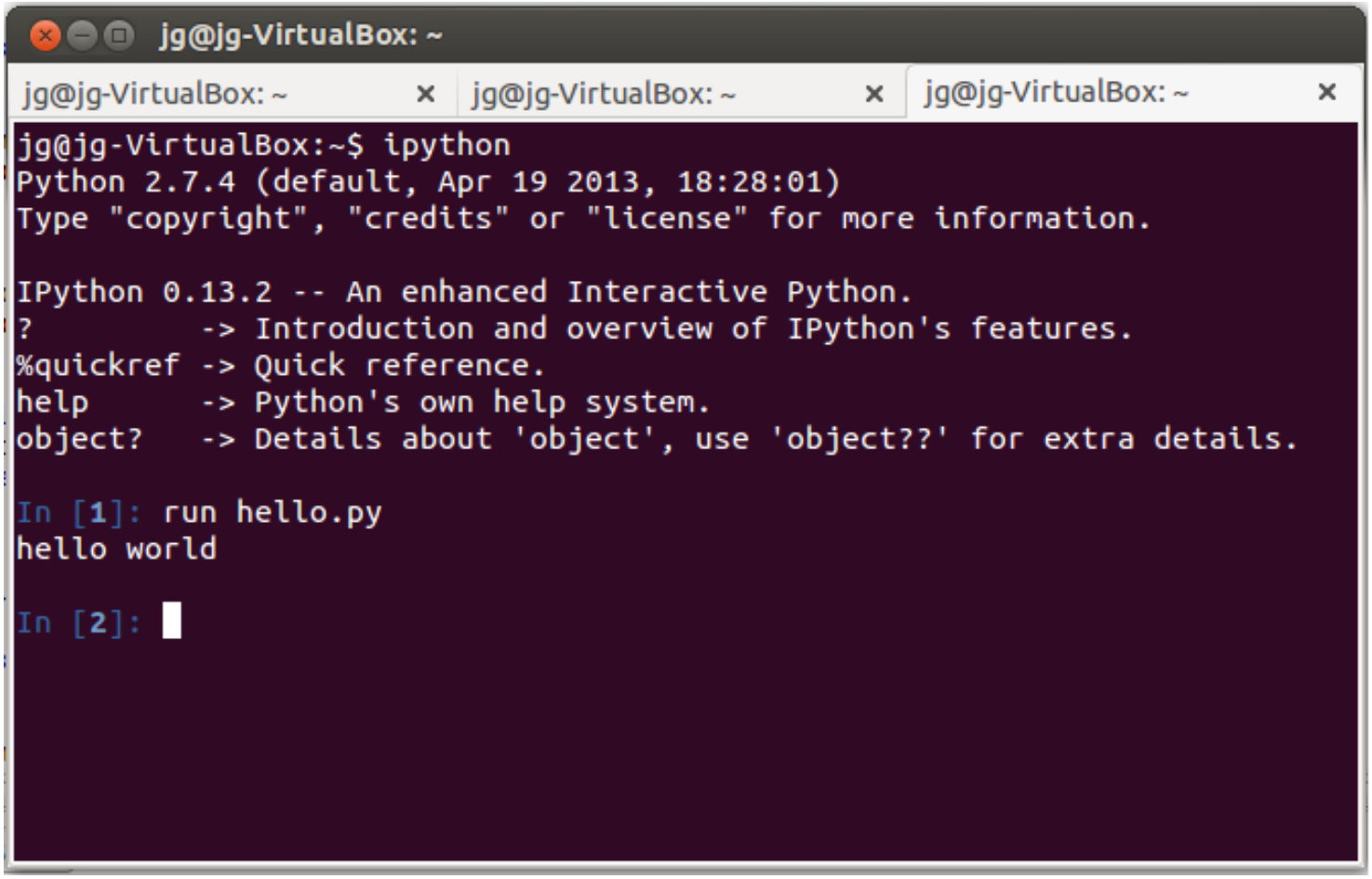
Option C: interactive

IPython (Windows, Linux, Mac)



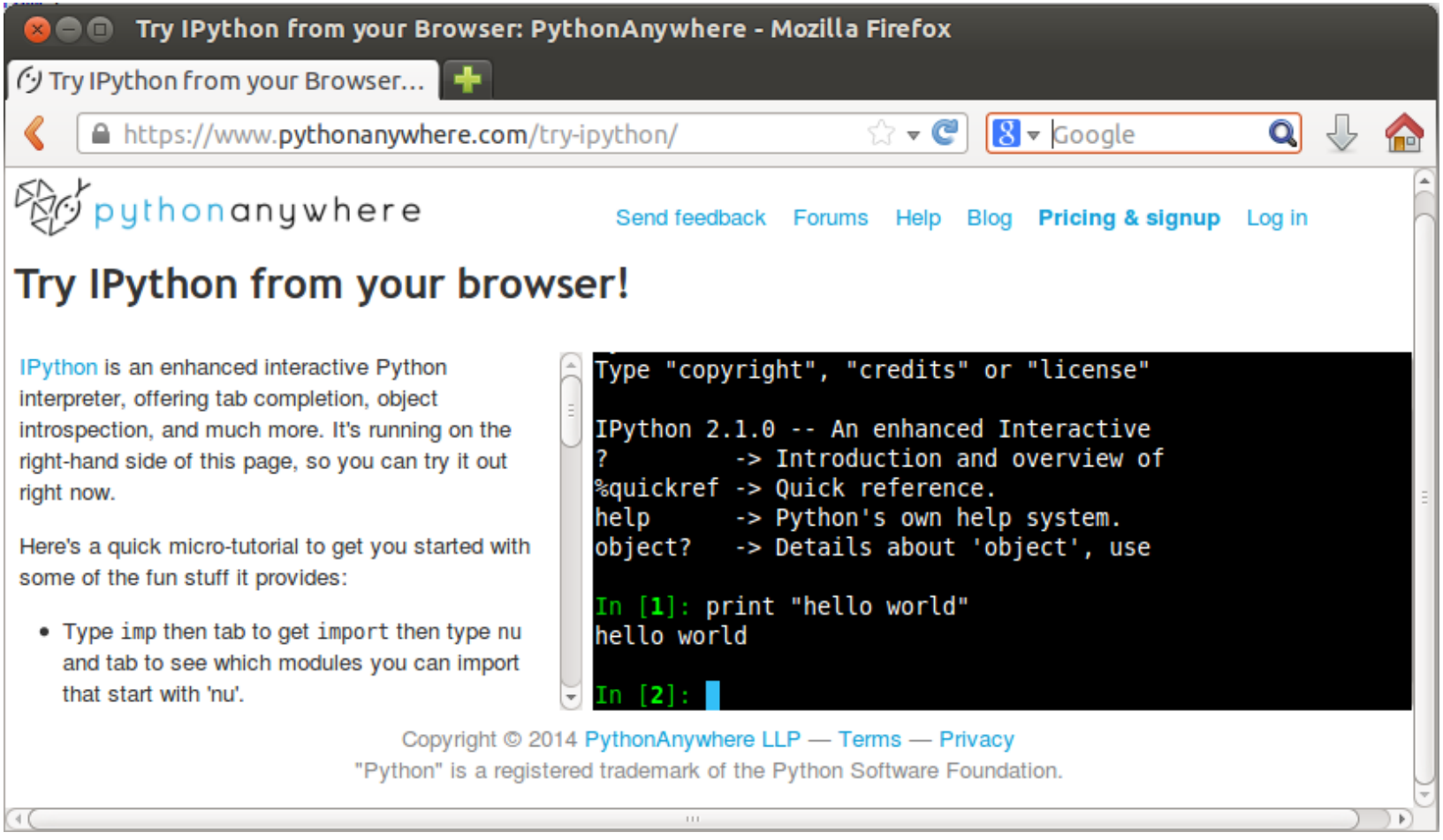
Option C: interactive

IPython (Windows, Linux, Mac)



Option C: interactive

IPython (Web)



Option C: interactive

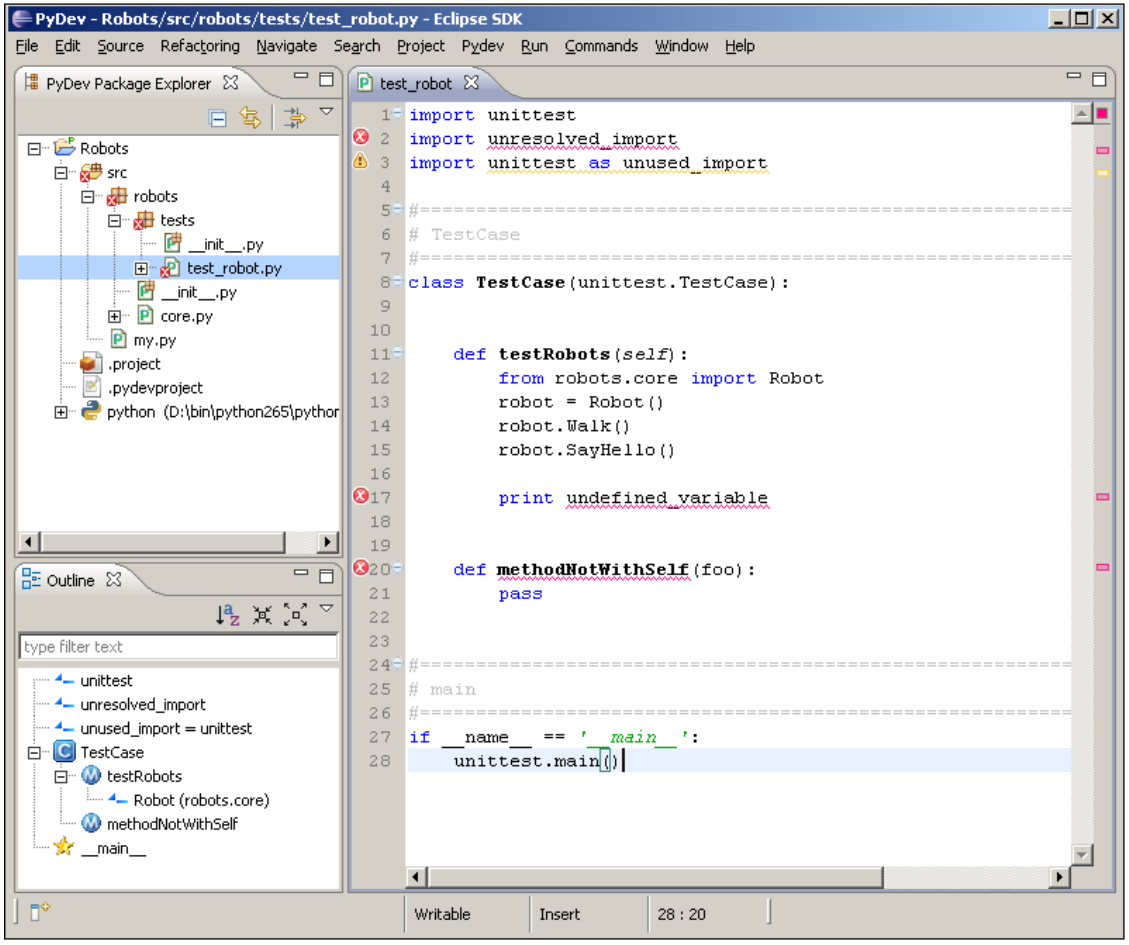
What you get

- Tab completion
- Command history

To paste in IPython, type `%paste`

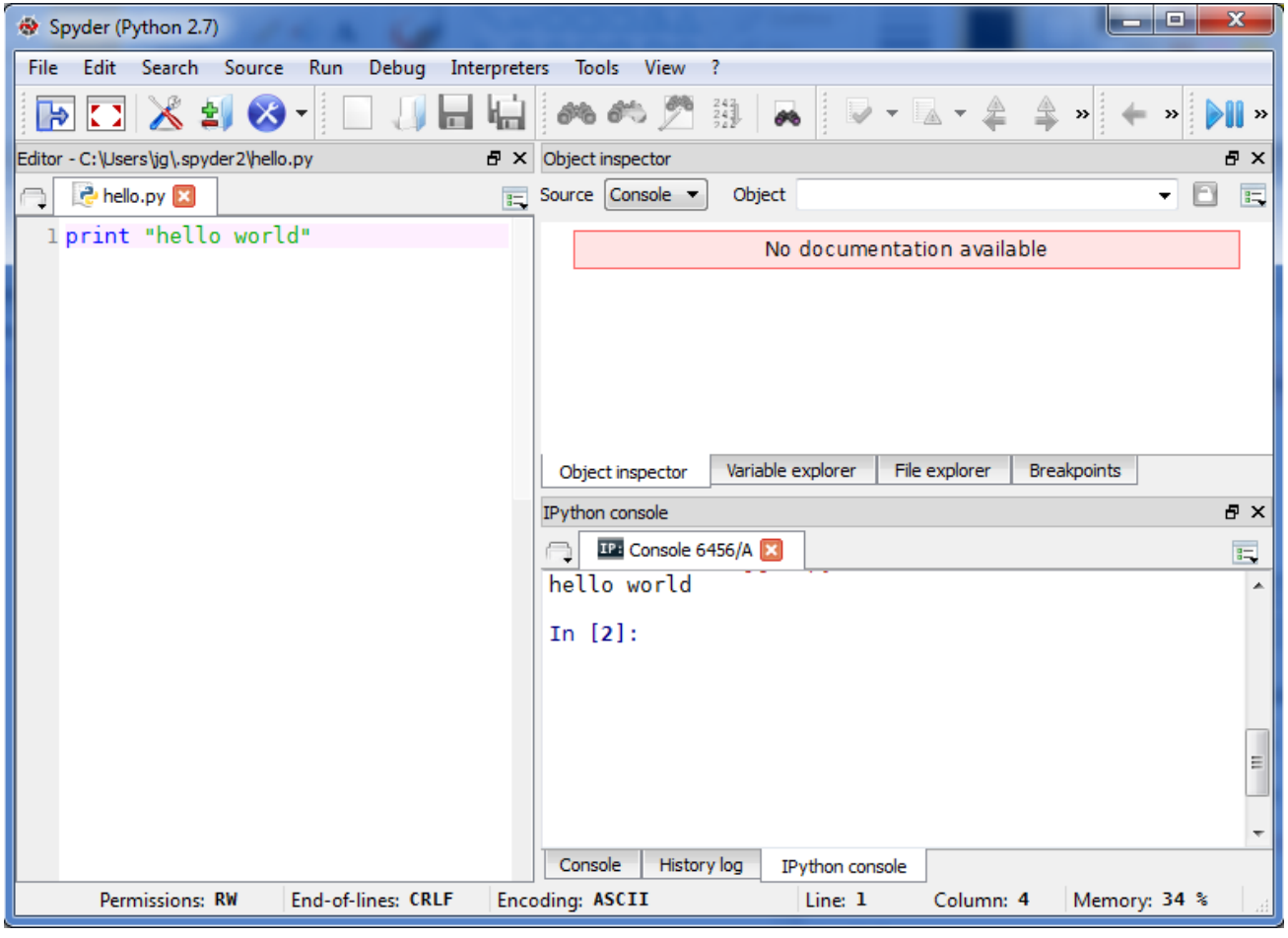
Option D: integrated development environment (IDE)

Eclipse (Windows, Linux, Mac)



Option D: integrated development environment (IDE)

Spyder (Windows, Linux, Mac)



Option D: integrated development environment (IDE)

What you get

- Syntax highlighting
- Tab completion
- Command history
- Debugging tools
- Static code analysis

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Syntax: assignment

```
variable = object
```

Properties

- Every piece of data is an object
- A variable is a reference to an object
- The object stays alive as long as some variable points to it (reference counted)

Datatypes: integer

```
a = 3
```

Properties

- Immutable

Datatypes: integer

```
a = 3
```

Properties

- Immutable

```
a =  a + 1
a += 1
```

Datatypes: integer

```
a = 3
```

Properties

- Immutable

```
a =  a + 1
a += 1
```

```
a = 1/2 #  a = 0
```

Datatypes: bool

```
a = True
a = False
```

Properties

- Immutable

Datatypes: float

```
a = 2.0
a = 2e-3
```

Datatypes: float

```
a = 2.0
a = 2e-3
```

Properties

- Immutable

```
print a <= 0, a+1
```

```
False, 1.002
```

Datatypes: str

```
a = "spam"
a = 'spam'
a = "hello\nworld"
```

Properties

- Immutable

Datatypes: str

```
a = "spam"
a = 'spam'
a = "hello\nworld"
```

Properties

- Immutable

```
print a
print "world" in a, "spam" + "eggs", "spam" * 3
```

```
hello
world
True, spameggs, spamspamspam
```

Datatypes: str

```
a = "spam"
a = 'spam'
a = "hello\nworld"
```

```
hello
world
True, spameggs, spamspamspam
```

Datatypes: set

```
a = {}       # empty set
a = {"spam",3}
a = {3}
a = {1,2,3}
```

Properties

- Unordered
- No duplicates
- Mutable

Datatypes: set

```
a = {}       # empty set
a = {"spam",3}
a = {3}
a = {1,2,3}
```

Properties

- Unordered
- No duplicates
- Mutable

```
print 2 in a, 5 in a
print a.union({2,5})
```

```
True, False
set([1, 2, 3, 5])
```

Datatypes: list

```
a = ["spam",3]
a = []    # empty list
a = [1,2,3]
```

Properties

- Ordered
- Duplicates allowed
- Mutable

Datatypes: list

```
a = ["spam",3]
a = []    # empty list
a = [1,2,3]
```

Properties

- Ordered
- Duplicates allowed
- Mutable

```
print a[0], 2 in a, a.index(2)
```

```
1, True, 1
```

Datatypes: tuple

```
a = (1,2,3)
a = ("spam",3)
a = (3,) # note trailing comma
a = ()   # empty tuple
```

Properties

- Ordered
- Duplicates allowed
- Immutable

Datatypes: dict

```
a = {"spam": 3, "eggs": 1}
a = {3 : "spam", (1,2):  "eggs"}
a = dict()    # empty dictionary
a = dict(spam=3,eggs=1)
```

Properties

- Unordered
- No duplicate keys allowed
- Immutable

Keys must be of immutable type

Datatypes: dict

```
a = dict(spam=3,eggs=1)
```

```
print "spam" in a, "eggs" in a, "foo" in a
print "spam" in a.keys()
print 3 in a, 3 in a.values()
```

```
True True False
True
False True
```

Syntax: assignment (2)

Recall

- Every piece of data is an object
- A variable is a reference to an object
- The object stays alive as long as some variable points to it (reference counting)

```
a = {"spam": 3, "eggs": 1}
a = 6
```

Syntax: assignment (2)

Recall

- Every piece of data is an object
- A variable is a reference to an object
- The object stays alive as long as some variable points to it (reference counting)

```
a = [1,2,3]
b = a
b[0] = 7
print a
```

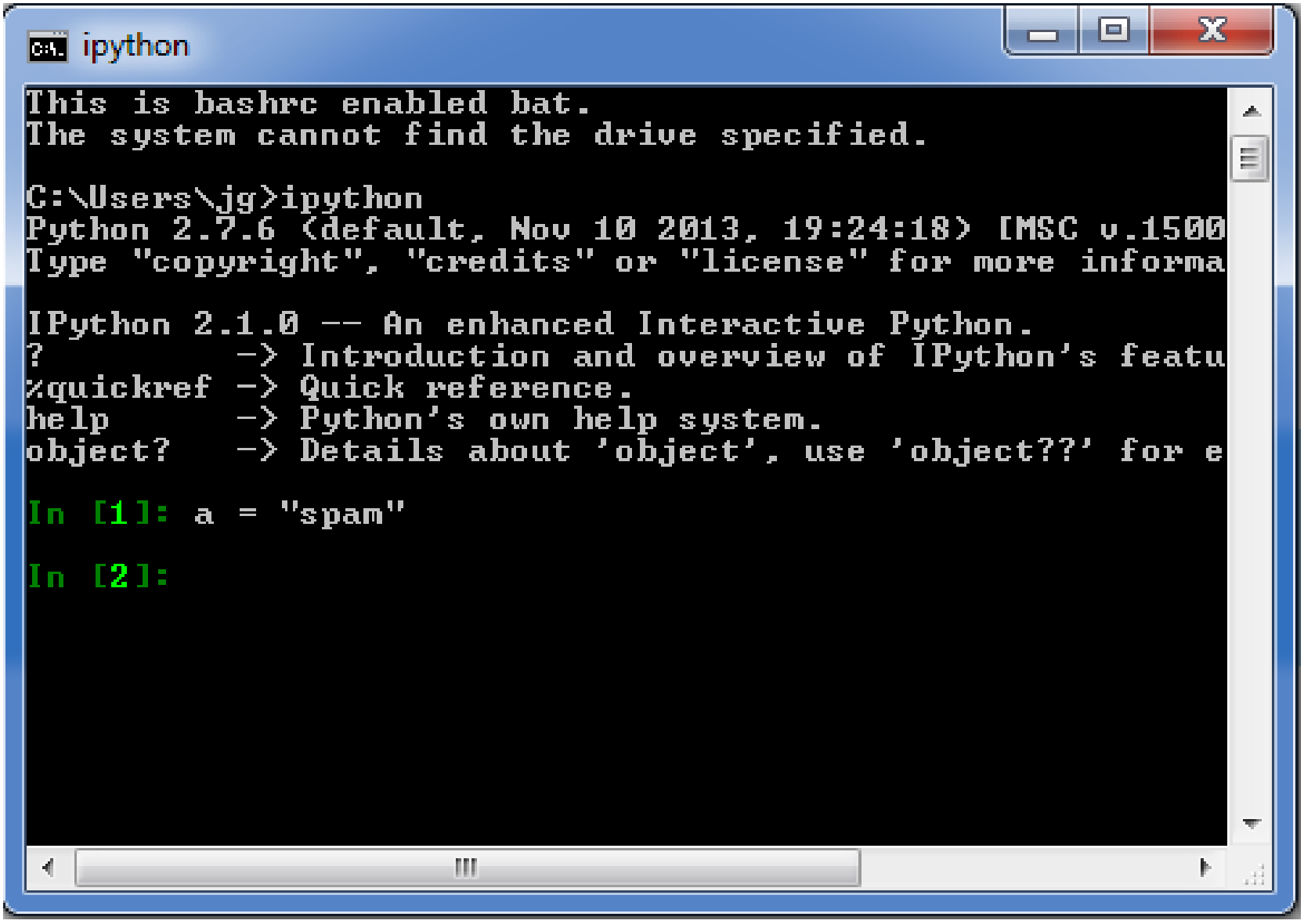
```
[7, 2, 3]
```

Objects

Observation

- Everything is an object . . .
- . . . so everything has methods and attributes

Objects


ipython
This is bashrc enabled bat.
The system cannot find the drive specified.
C:\Users\jg>ipython
Python 2.7.6 (default, Nov 10 2013, 19:24:18) [MSC v.1500
Type "copyright", "credits" or "license" for more informa
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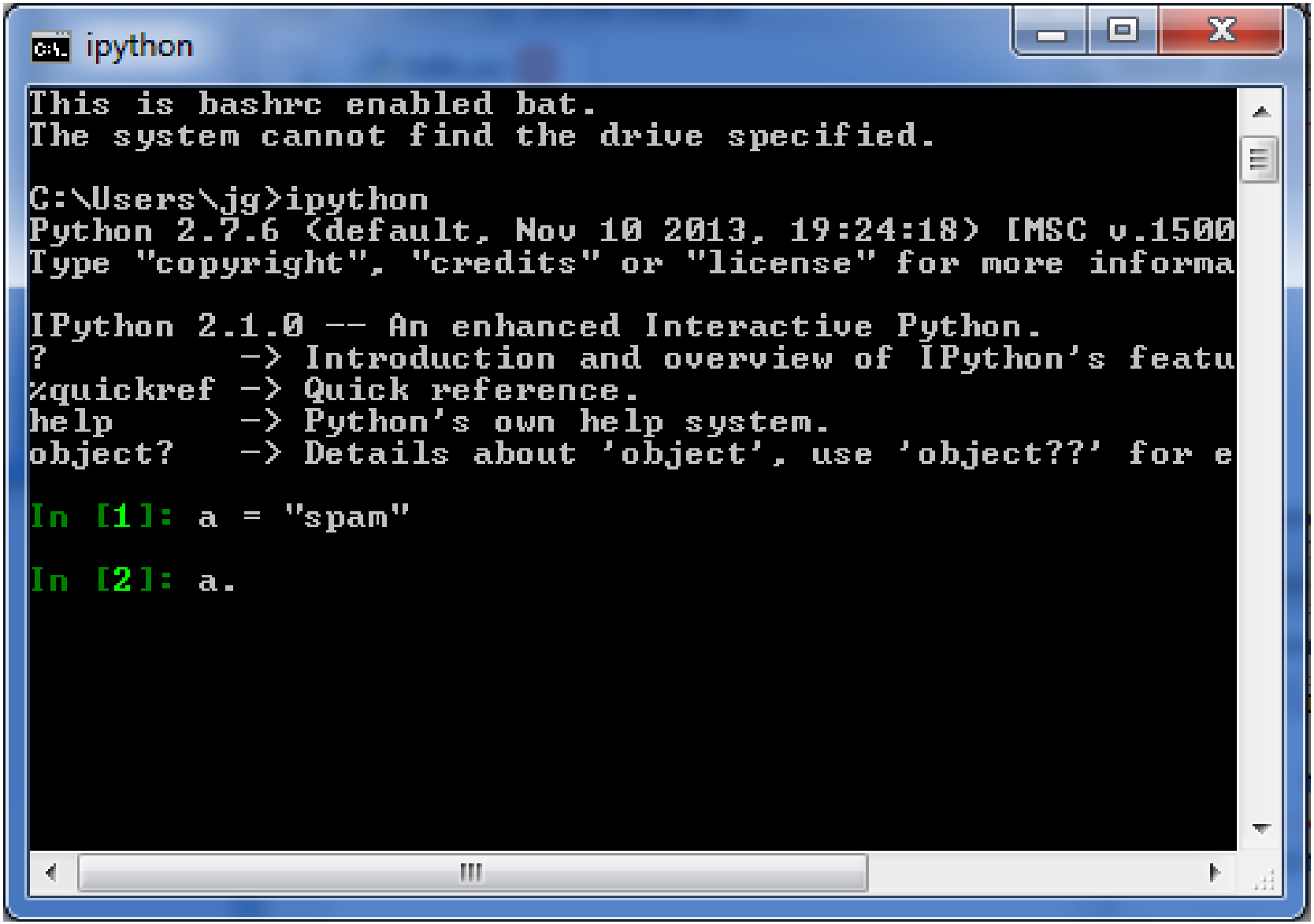
? -> Introduction and overview of IPython's featu
%quickref -> Quick reference.
help -> Python's own help system.
object? -> Details about 'object', use 'object??' for e
In [1]: a = "spam"
In [2]:

Objects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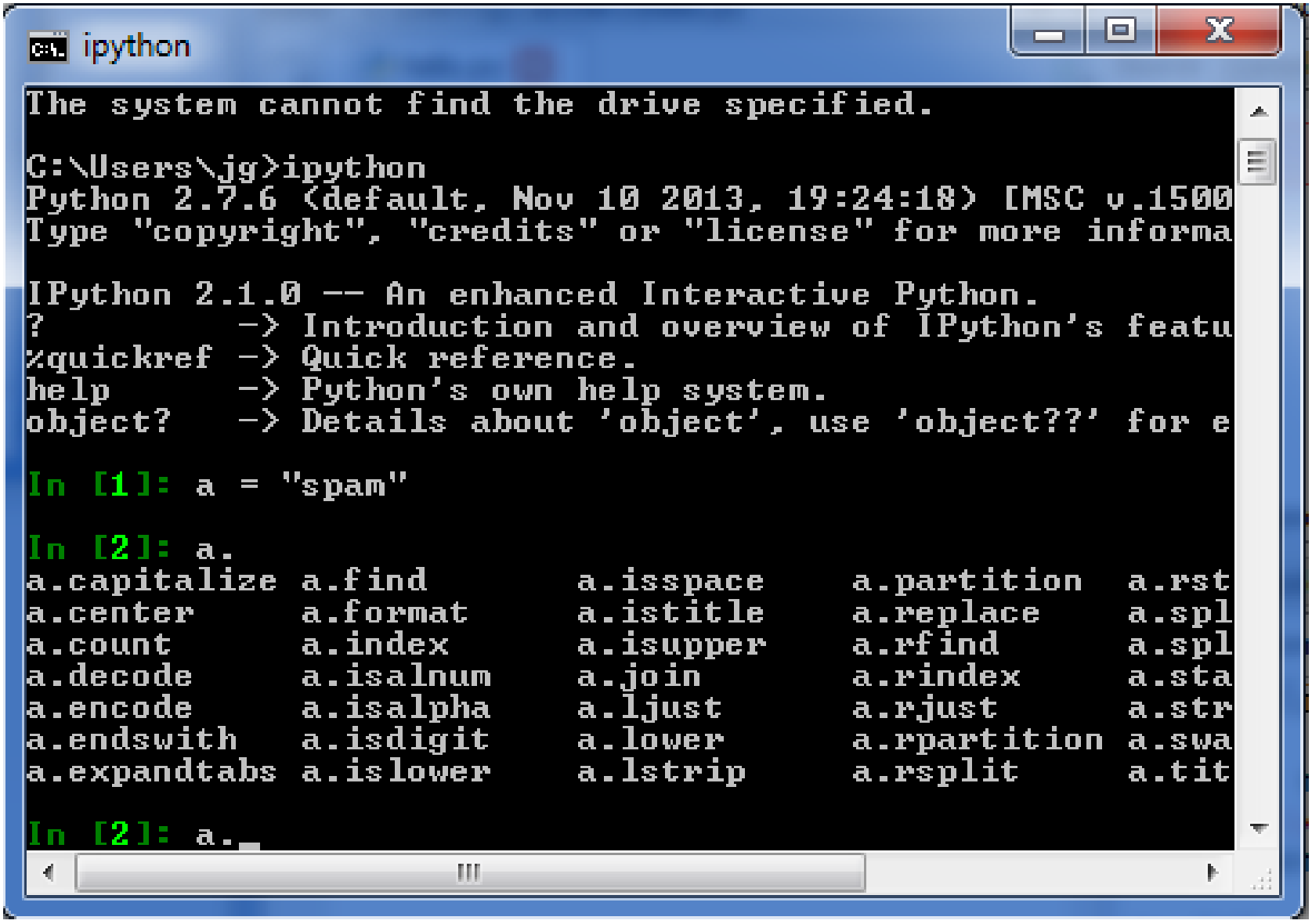
Objects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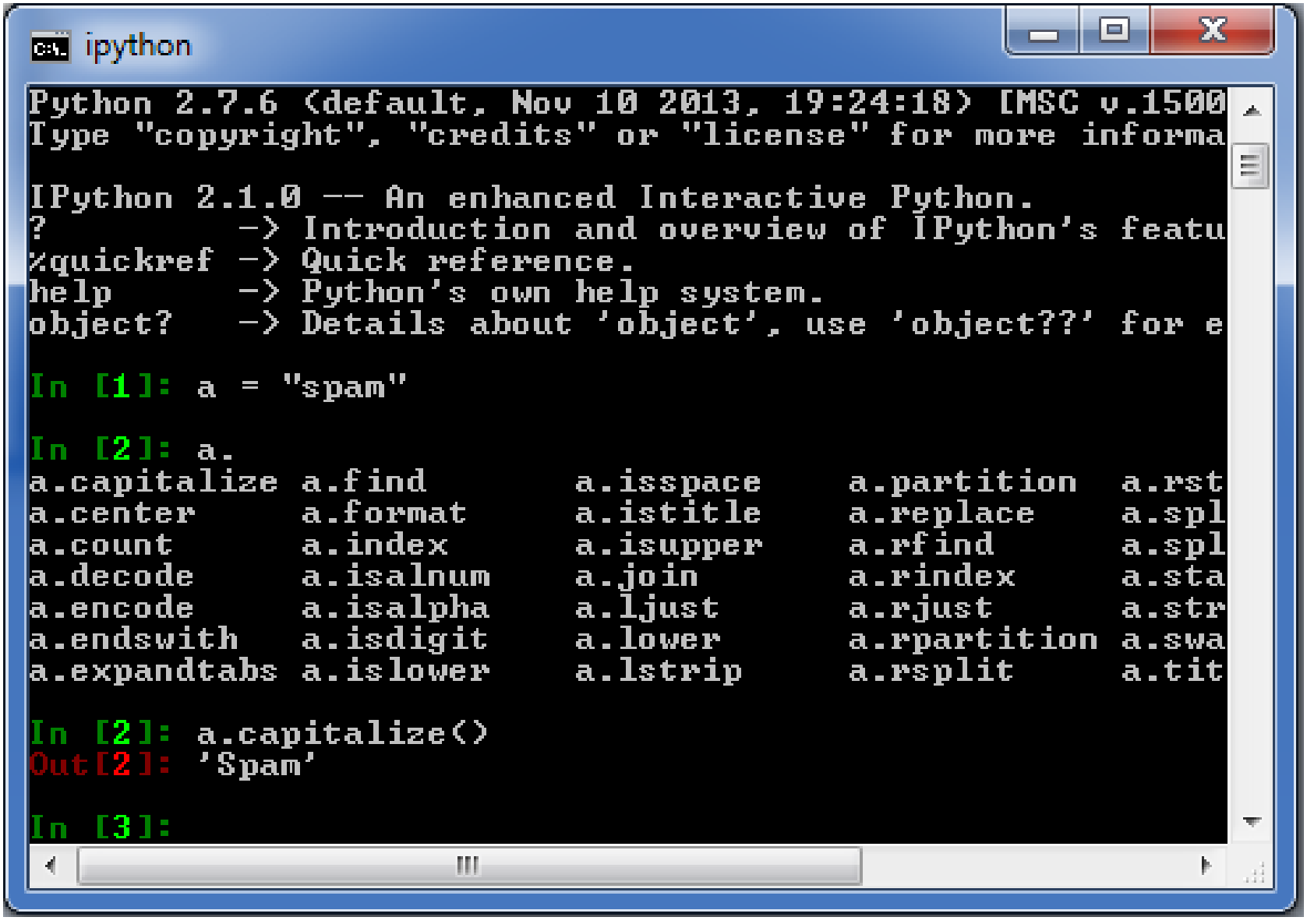
In [1]: a = "spam"
In [2]: a.
a.capitalize a.find a.isspace a.partition a.rst
a.center a.format a.istitle a.replace a.spl
a.count a.index a.isupper a.rfind a.spl
a.decode a.isalnum a.join a.rindex a.sta
a.encode a.isalpha a.ljust a.rjust a.str
a.endswith a.isdigit a.lower a.rpartition a.swa
a.expandtabs a.islower a.lstrip a.rsplit a.tit
In [2]: a._

Objects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In [1]: a = "spam"
In [2]: a.
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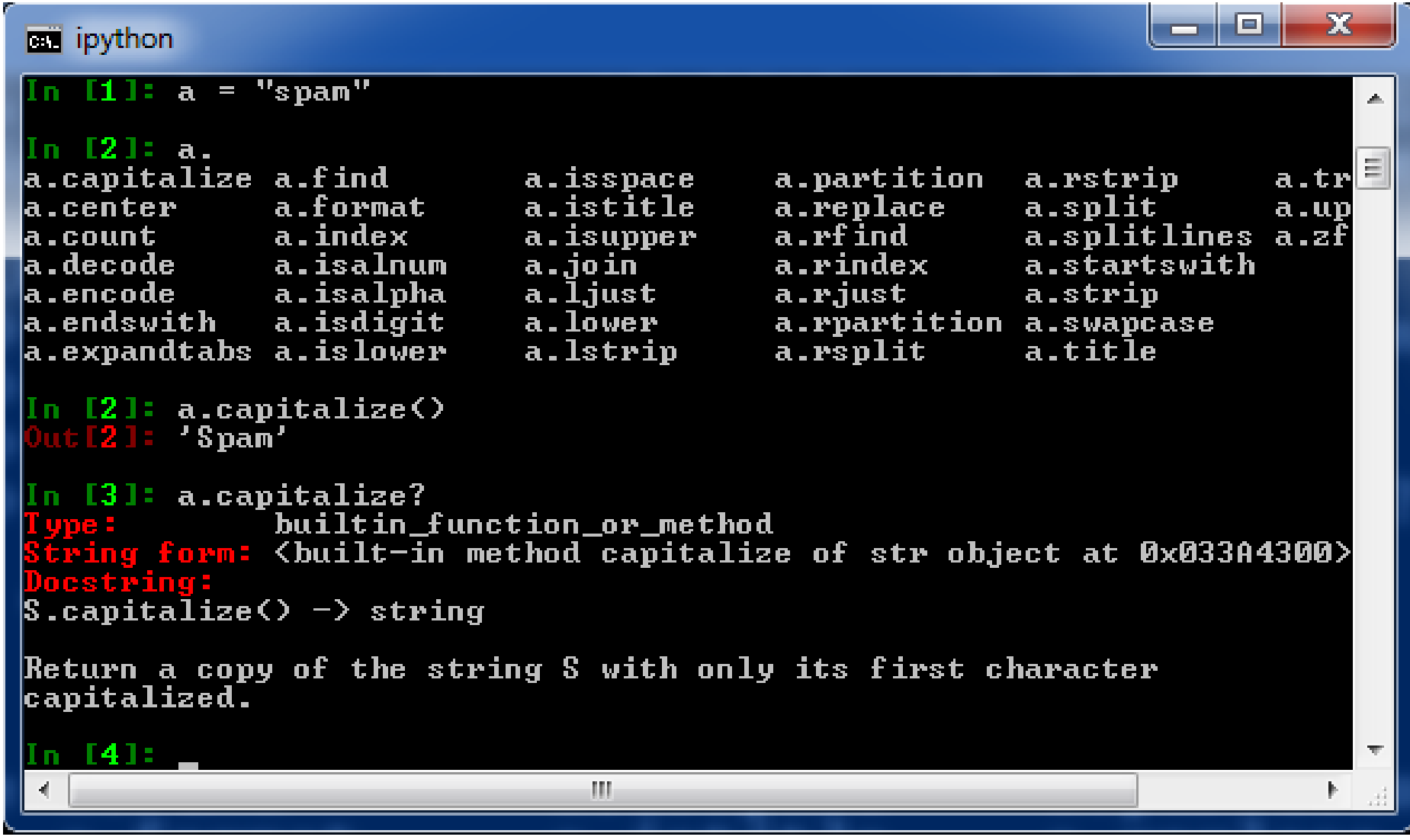
a.center a.format a.istitle a.replace a.spl
a.count a.index a.isupper a.rfind a.spl
a.decode a.isalnum a.join a.rindex a.sta
a.encode a.isalpha a.ljust a.rjust a.str
a.endswith a.isdigit a.lower a.rpartition a.swa
a.expandtabs a.islower a.lstrip a.rsplit a.tit
In [2]: a.capitalize()
Out[2]: 'Spam'
In [3]:

Objects

Observation

- Everything is an object . . .
- . . . so everything has methods
- . . . and everything has documentation

Objects

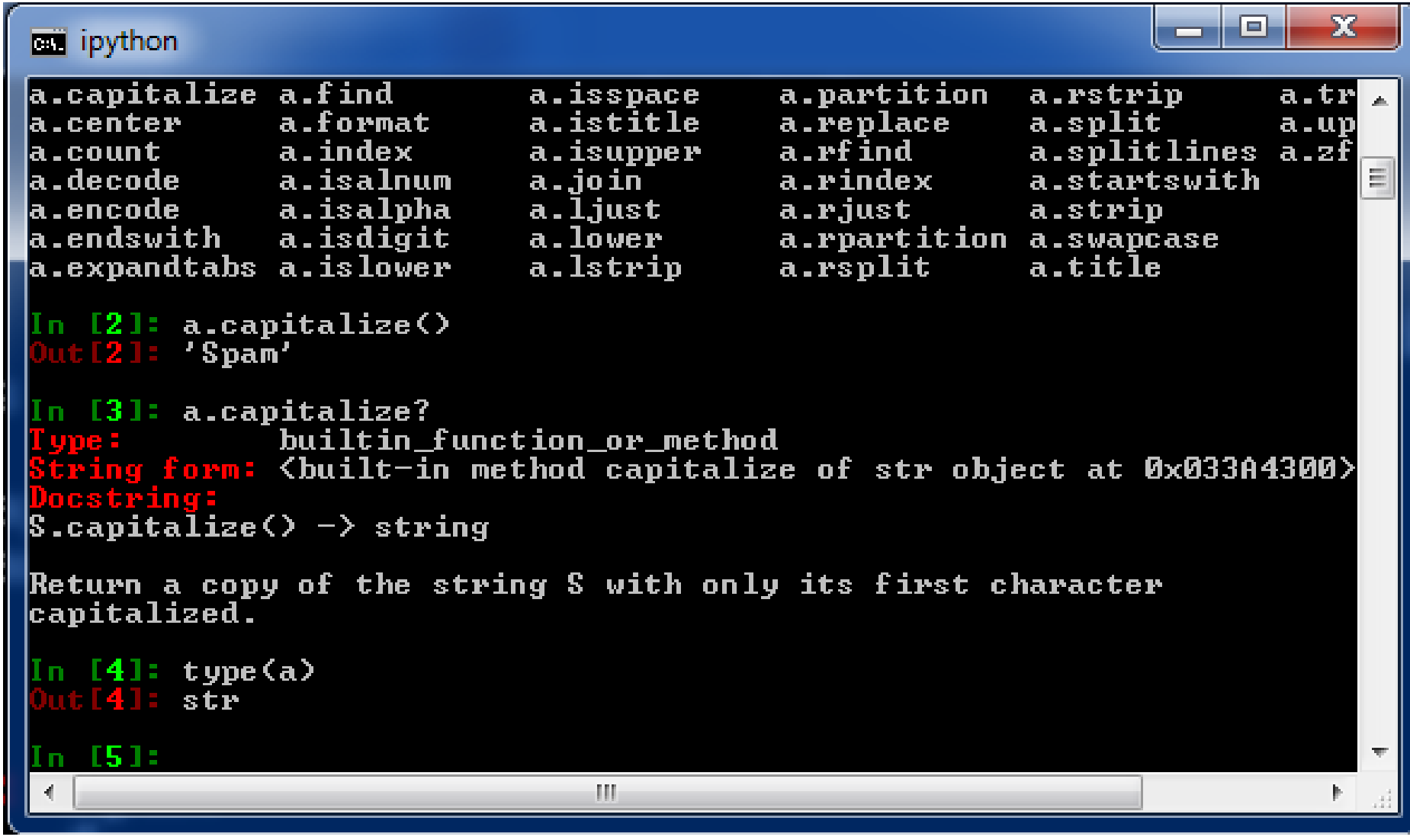

ipython
In [1]: a = "spam"
In [2]: a.
a.capitalize a.find a.isspace a.partition a.rstrip a.tr
a.center a.format a.istitle a.replace a.split a.up
a.count a.index a.isupper a.rfind a.splitlines a.zf
a.decode a.isalnum a.join a.rindex a.startswith
a.encode a.isalpha a.ljust a.rjust a.strip
a.endswith a.isdigit a.lower a.rpartition a.swapcase
a.expandtabs a.islower a.lstrip a.rsplit a.title
In [2]: a.capitalize()
Out[2]: 'Spam'
In [3]: a.capitalize?
Type: builtin_function_or_method
String form: <built-in method capitalize of str object at 0x033A4300>
Docstring:
S.capitalize() -> string
Return a copy of the string S with only its first character
capitalized.
In [4]:

Objects

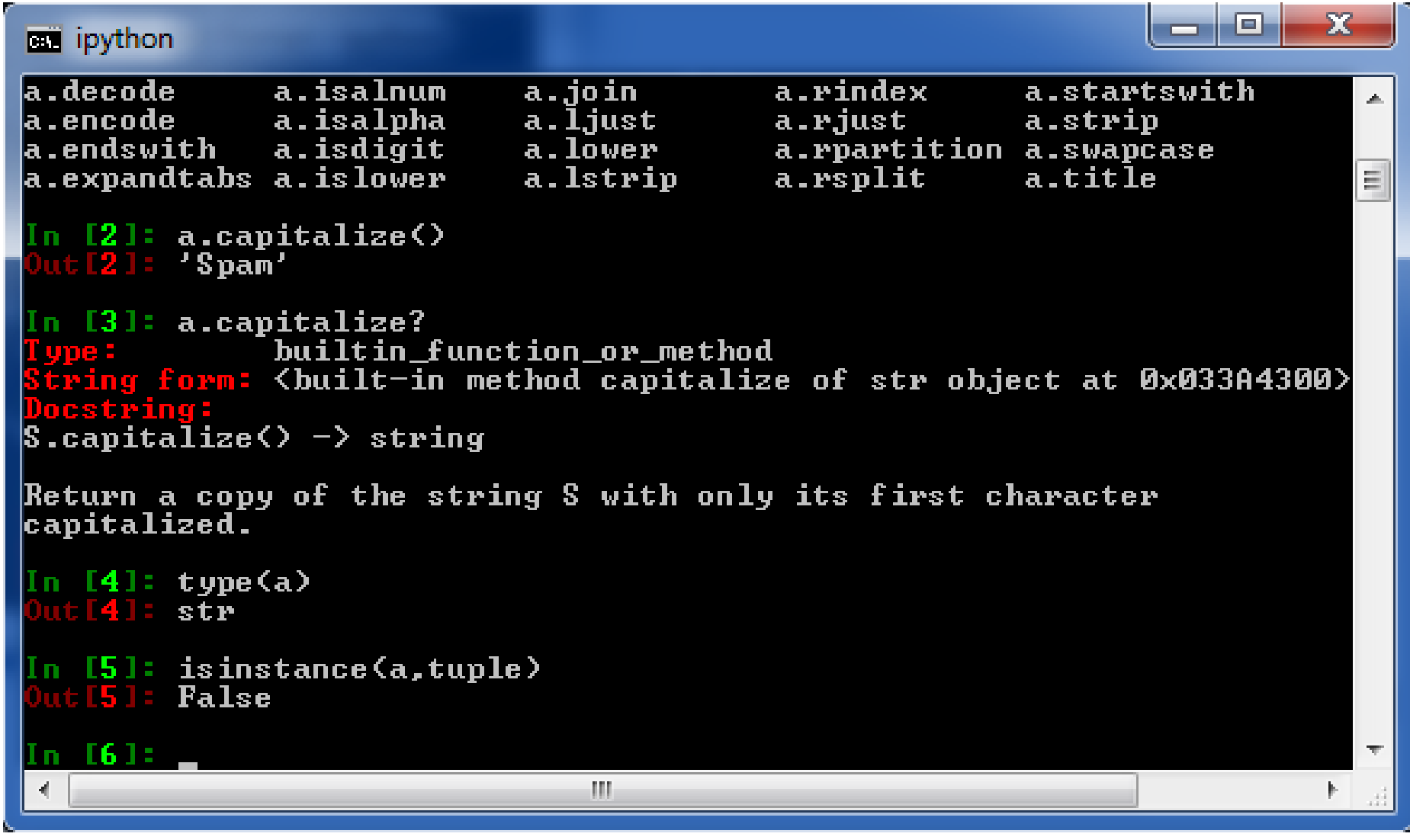
Observation

- Everything is an object . . .
- . . . so everything has methods
- . . . and everything has documentation
- . . . everything has a type

Objects


ipython
a.capitalize a.find a.isspace a.partition a.rstrip a.tr
a.center a.format a.istitle a.replace a.split a.up
a.count a.index a.isupper a.rfind a.splitlines a.zf
a.decode a.isalnum a.join a.rindex a.startswith
a.encode a.isalpha a.ljust a.rjust a.strip
a.endswith a.isdigit a.lower a.rpartition a.swapcase
a.expandtabs a.islower a.lstrip a.rsplit a.title
In [2]: a.capitalize()
Out[2]: 'Spam'
In [3]: a.capitalize?
Type: builtin_function_or_method
String form: <built-in method capitalize of str object at 0x033A4300>
Docstring:
S.capitalize() -> string
Return a copy of the string S with only its first character
capitalized.
In [4]: type(a)
Out[4]: str
In [5]:

Objects


ipython
a.decode a.isalnum a.join a.rindex a.startswith
a.encode a.isalpha a.ljust a.rjust a.strip
a.endswith a.isdigit a.lower a.rpartition a.swapcase
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In [2]: a.capitalize()
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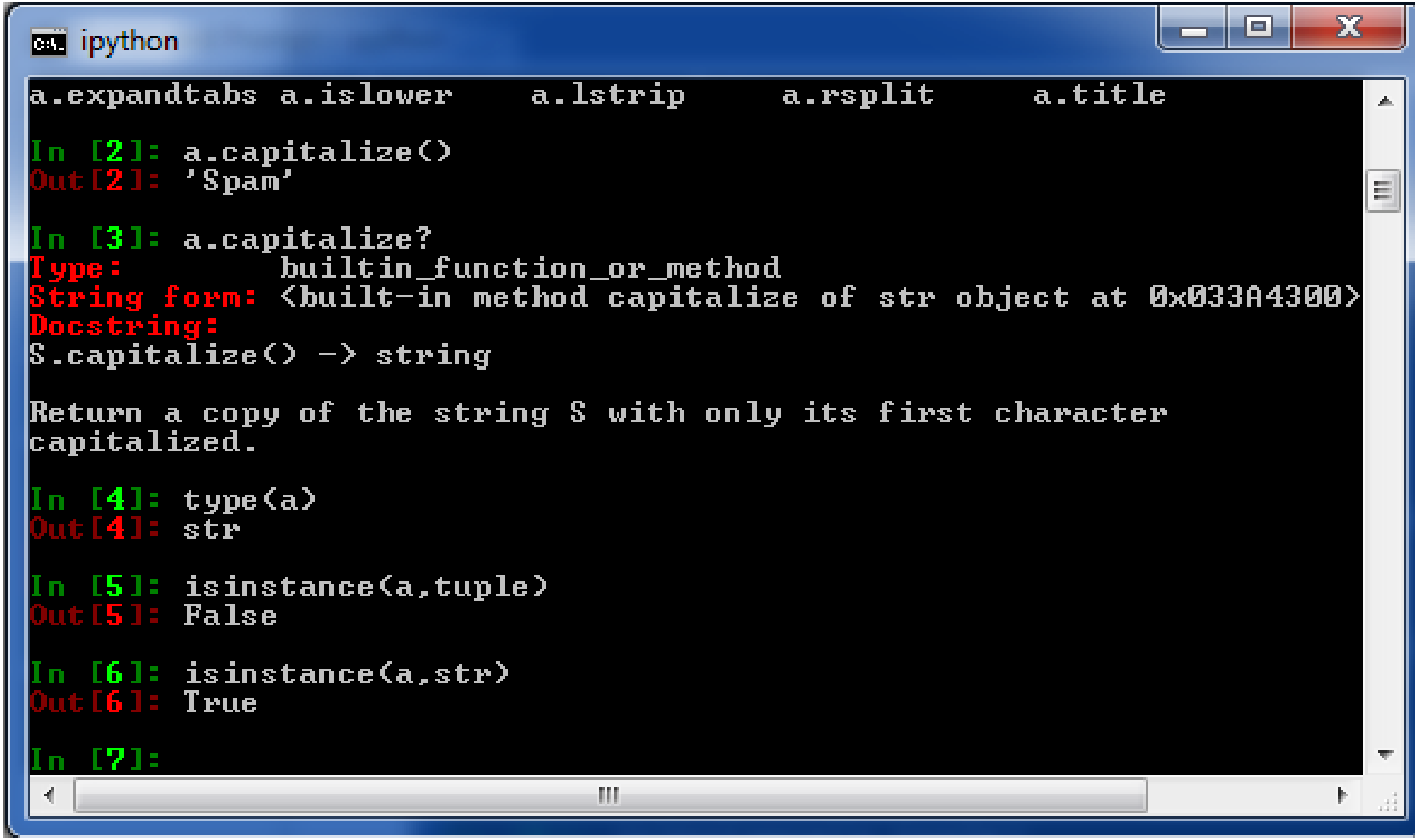
Docstring:
S.capitalize() -> string
Return a copy of the string S with only its first character
capitalized.
In [4]: type(a)
Out[4]: str
In [5]: isinstance(a,tuple)
Out[5]: False
In [6]:

Objects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String form: <built-in method capitalize of str object at 0x033A4300>
Docstring:
S.capitalize() -> string
Return a copy of the string S with only its first character
capitalized.
In [4]: type(a)
Out[4]: str
In [5]: isinstance(a,tuple)
Out[5]: False
In [6]: isinstance(a,str)
Out[6]: True
In [7]:

Functions

```
def spam():
  return "eggs"

print spam()
```

```
eggs
```

Indentation determines scope

Function arguments

```
def spam(a,b,c):
  return a+b+c

print spam(1,2,3)
```

```
6
```

Function arguments

```
def spam(*args):
  print args
  return sum(args)

print spam(1,2,3)
print spam(1,2,3,4)
```

```
(1,2,3)
6
(1,2,3,4)
10
```

Function arguments

```
def spam(a,b,c="everybody"):
  print "Greetings to %s! -- %d" % (c,a+b)

spam(1,2)
spam(3,4,c="you")
```

```
Greetings to everybody! -- 3
Greetings to you! -- 7
```

Function arguments

```
def spam(*args,**kwargs):
  print "Thanks for these arguments:"
  print "  args:", args
  print "  kwargs:", kwargs

spam("eggs",3,boilingtime=12,salt=True)
```

```
Thanks for these arguments:
  args: ('eggs', 3)
  kwargs: {'boilingtime': 12, 'salt': True}
```

Function arguments

Arguments are always passed by reference

```
def spam(eggs):
  eggs.append(2)

my_eggs = []
spam(my_eggs)

print my_eggs
```

```
[2]
```

Function arguments

```
def factorial(n):
  if n==0:
    return 1
  else:
    return n*factorial(n-1)

print factorial(5)
```

```
24
```

Function arguments

```
def factorial(n,partials=[]):
  partials.append(n)
  print partials
  if n==0:
    return 1
  else:
    return n*factorial(n-1,partials=partials)

print factorial(4)
```

```
[4]
[4, 3]
[4, 3, 2]
[4, 3, 2, 1]
[4, 3, 2, 1, 0]
24
```

A common pitfall

Function arguments

```
print factorial(4)
```

```
[4, 3, 2, 1, 0, 4]
[4, 3, 2, 1, 0, 4, 3]
[4, 3, 2, 1, 0, 4, 3, 2]
[4, 3, 2, 1, 0, 4, 3, 2, 1]
[4, 3, 2, 1, 0, 4, 3, 2, 1, 0]
24
```

Function arguments

```
def factorial(n,partials=None):
  if partials is None:
    partials = []
  partials.append(n)
  print partials
  if n==0:
    return 1
  else:
    return n*factorial(n-1,partials=partials)

print factorial(4)
print factorial(4)
```

```
[4]
[4, 3]
[4, 3, 2]
[4, 3, 2, 1]
[4, 3, 2, 1, 0]
24
[4]
```

Flow control

```
teachers = ["moritz","joel","greg","joris"]

for p in teachers:
  print p.capitalize()
```

```
Moritz
Joel
Greg
Joris
```

Flow control

```
for i in range(4):
  print i
```

```
0
1
2
3
```

Flow control

```
teachers = ["moritz","joel","greg","joris"]

for i in range(len(teachers)):
  print i, teachers[i]
```

```
0 moritz
1 joel
2 greg
3 joris
```

Flow control

```
teachers = ["moritz","joel","greg","joris"]

for i in range(len(teachers)):
  print i, teachers[i]
```

```
0 moritz
1 joel
2 greg
3 joris
```

This is unpythonic

Flow control

```
teachers = ["moritz","joel","greg","joris"]

for i, p in enumerate(teachers):
  print i, p
```

```
0 moritz
1 joel
2 greg
3 joris
```

This is pythonic

List comprehension

```
teachers = "moritz joel greg joris".split(" ")

namelengths = []
for p in teachers:
  namelengths.append(len(p))

print namelengths
```

```
[6, 4, 4, 5]
```

This is unpythonic

List comprehension

```
teachers = "moritz joel greg joris".split(" ")

namelengths = [len(p) for p in teachers]

print namelengths
```

```
[6, 4, 4, 5]
```

This is pythonic

Flow control

```
teachers = ["moritz","joel","greg","joris"]
homes = ["Freiburg","Barcelona","Freiburg","Leuven"]

for i in range(len(teachers)):
  print "%s lives in %s" % (teachers[i],homes[i])
```

```
moritz lives in Freiburg
joel lives in Barcelona
greg lives in Freiburg
joris lives in Leuven
```

This is unpythonic

Flow control

```
teachers = ["moritz","joel","greg","joris"]
homes = ["Freiburg","Barcelona","Freiburg","Leuven"]

for t, p in zip(teachers,homes):
  print "%s lives in %s" % (t.capitalize(),p)
```

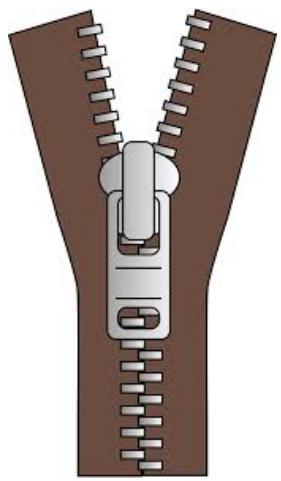
```
Moritz lives in Freiburg
Joel lives in Barcelona
Greg lives in Freiburg
Joris lives in Leuven
```

This is pythonic

Flow control

```
teachers = ["moritz","joel","greg","joris"]
homes = ["Freiburg","Barcelona","Freiburg","Leuven"]

print zip(teachers,homes)
```

```
[('moritz', 'Freiburg'), ('joel', 'Barcelona'),
('greg', 'Freiburg'), ('joris', 'Leuven')]
```



Flow control

```
[('moritz', 'Freiburg'), ('joel', 'Barcelona'),
('greg', 'Freiburg'), ('joris', 'Leuven')]
```

```
for t, p in zip(teachers,homes):
  code
```

Flow control

```
[('moritz', 'Freiburg'), ('joel', 'Barcelona'),
('greg', 'Freiburg'), ('joris', 'Leuven')]
```

```
for t, p in zip(teachers,homes):
  code
```

```
t, p = ('moritz', 'Freiburg')
code
t, p = ('joel', 'Barcelona')
code
...
```

Flow control

```
d = dict()

for t, p in zip(teachers,homes):
  d[t] = p

print d
```

```
{'joris': 'Leuven', 'joel': 'Barcelona',
'greg': 'Freiburg', 'moritz': 'Freiburg'}
```

Flow control

```
d = dict(zip(teachers,homes))

print d
```

```
{'joris': 'Leuven', 'joel': 'Barcelona',
'greg': 'Freiburg', 'moritz': 'Freiburg'}
```

More pythonic

Flow control

```
for t, p in d.items():
  print "%s lives in %s" % (t.capitalize(),p)
```

```
Moritz lives in Freiburg
Joel lives in Barcelona
Greg lives in Freiburg
Joris lives in Leuven
```

More pythonic

Using packages

The creative cycle in Python

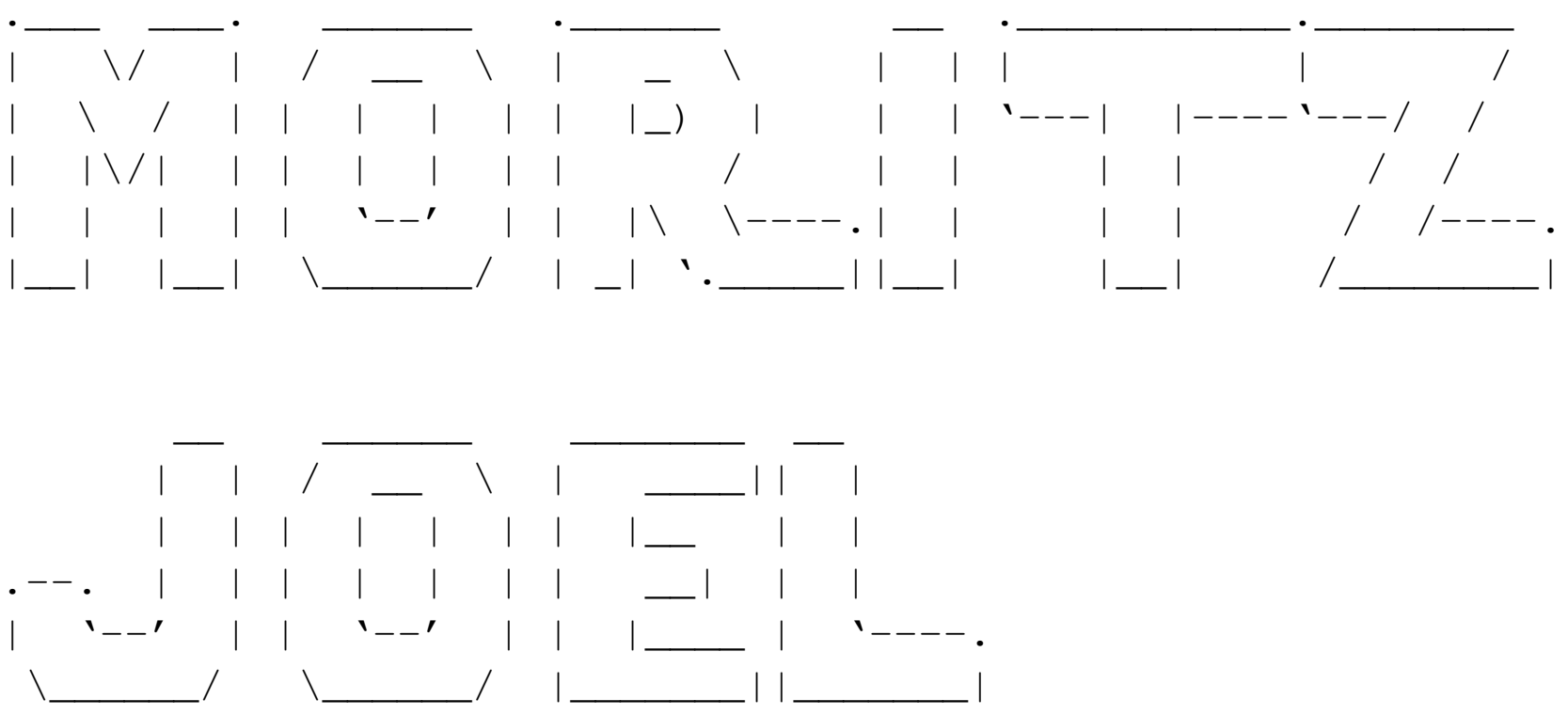
1. Imagine it (ascii art)
2. Google it (pyfiglet)
3. Install it (`pip install pyfiglet` – Windows, Linux, Mac)
4. Import it

Using packages

```
import pyfiglet

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print pyfiglet.figlet_format(t,font="starwars")
```

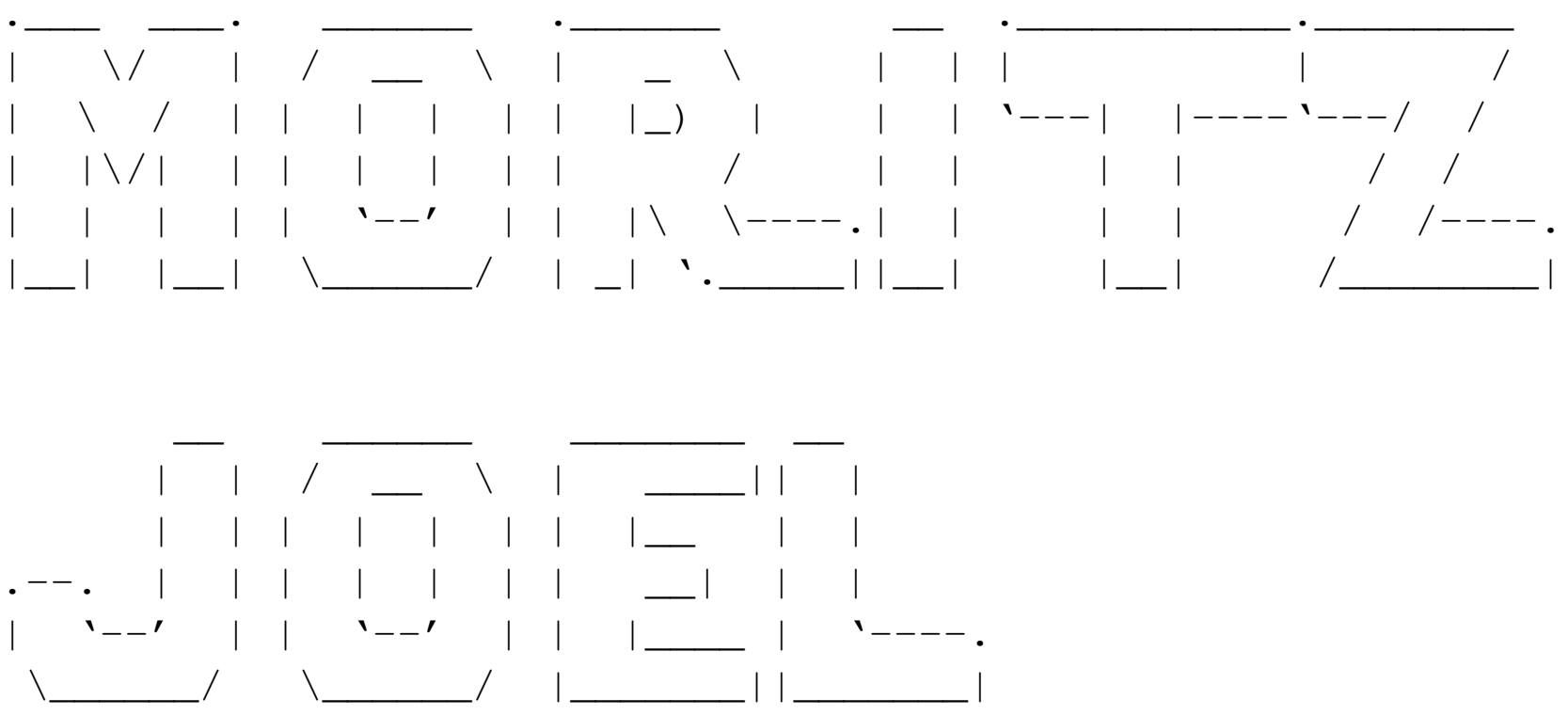
Using packages

```
import pyfiglet

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print pyfiglet.figlet_format(t,font="starwars")
```



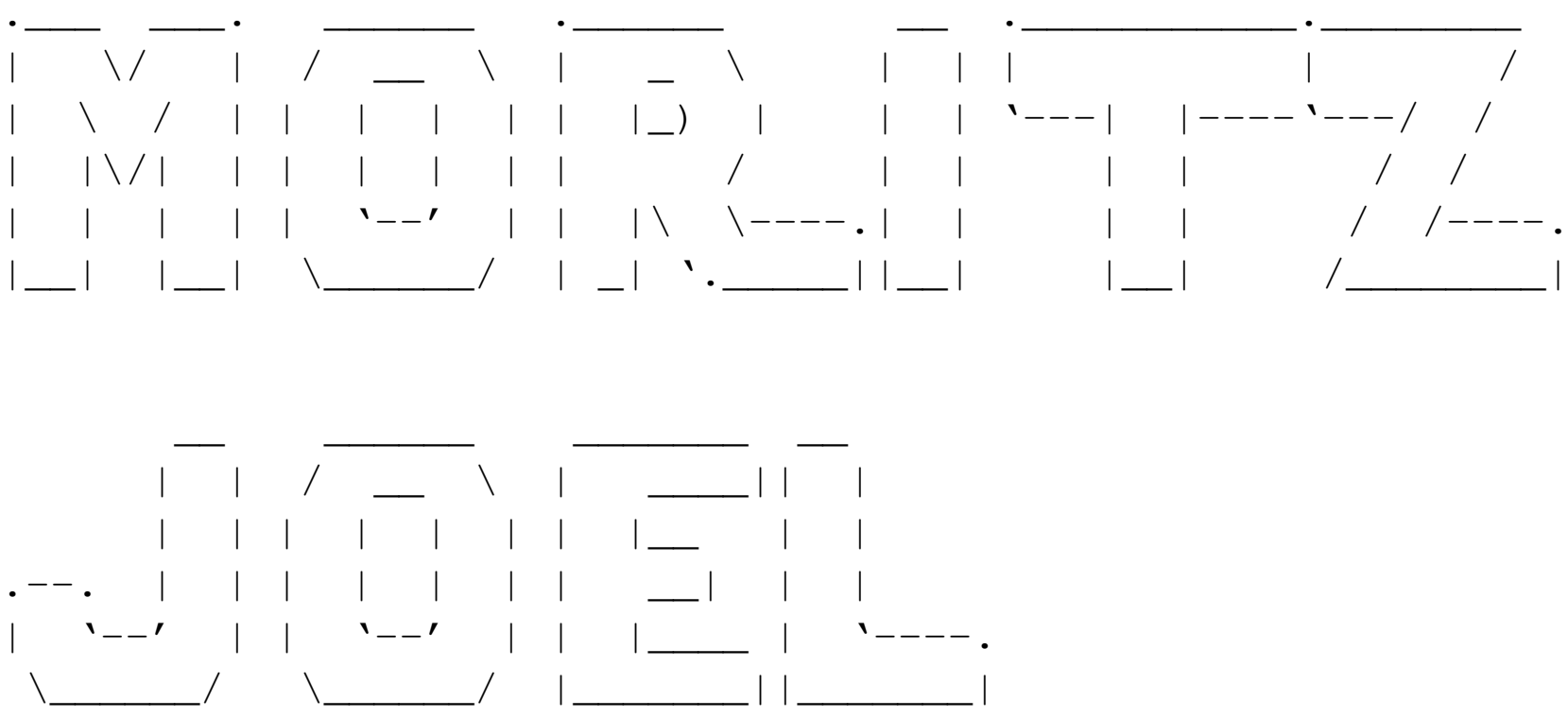
Using packages

```
import pyfiglet as pf

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print pf.figlet_format(t,font="starwars")
```



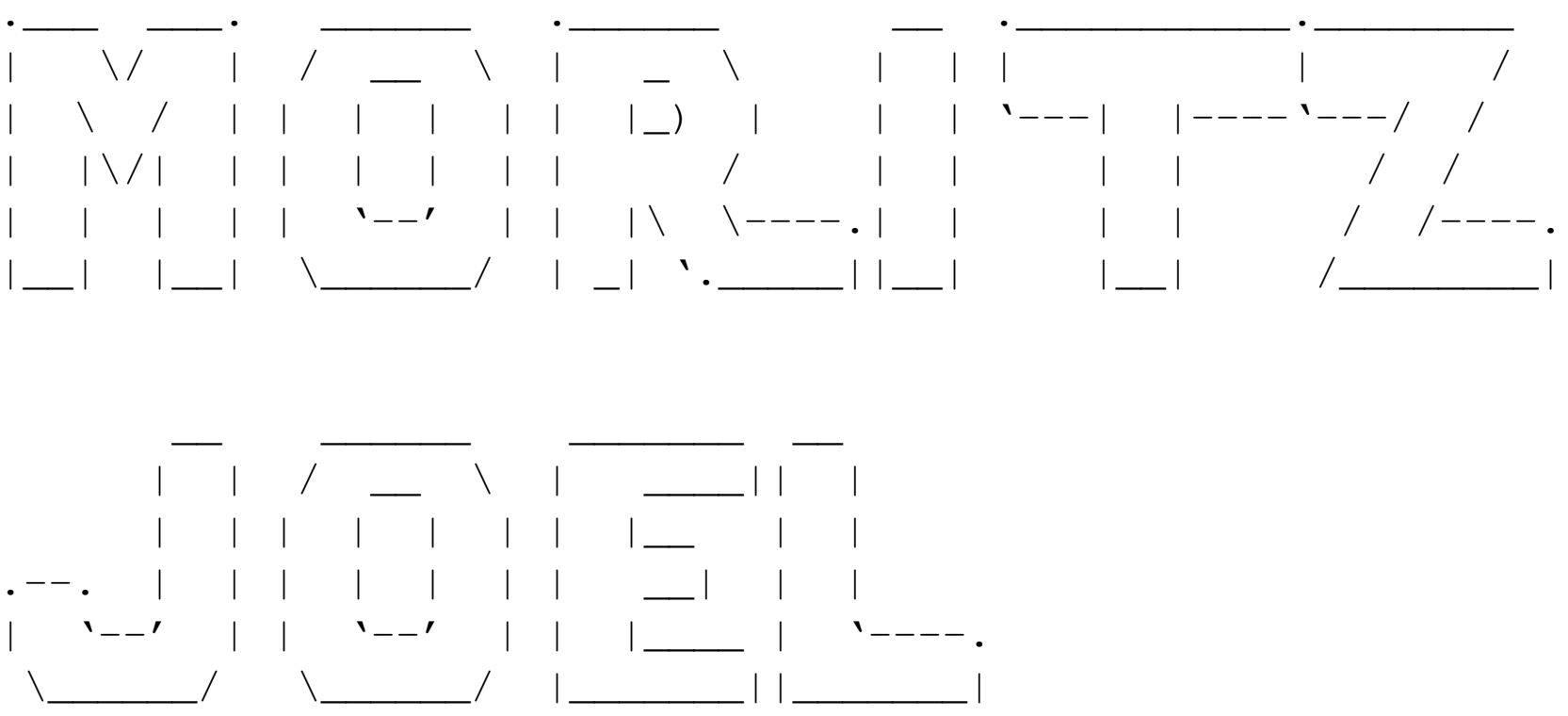
Using packages

```
from pyfiglet import figlet_format

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print figlet_format(t,font="starwars")
```



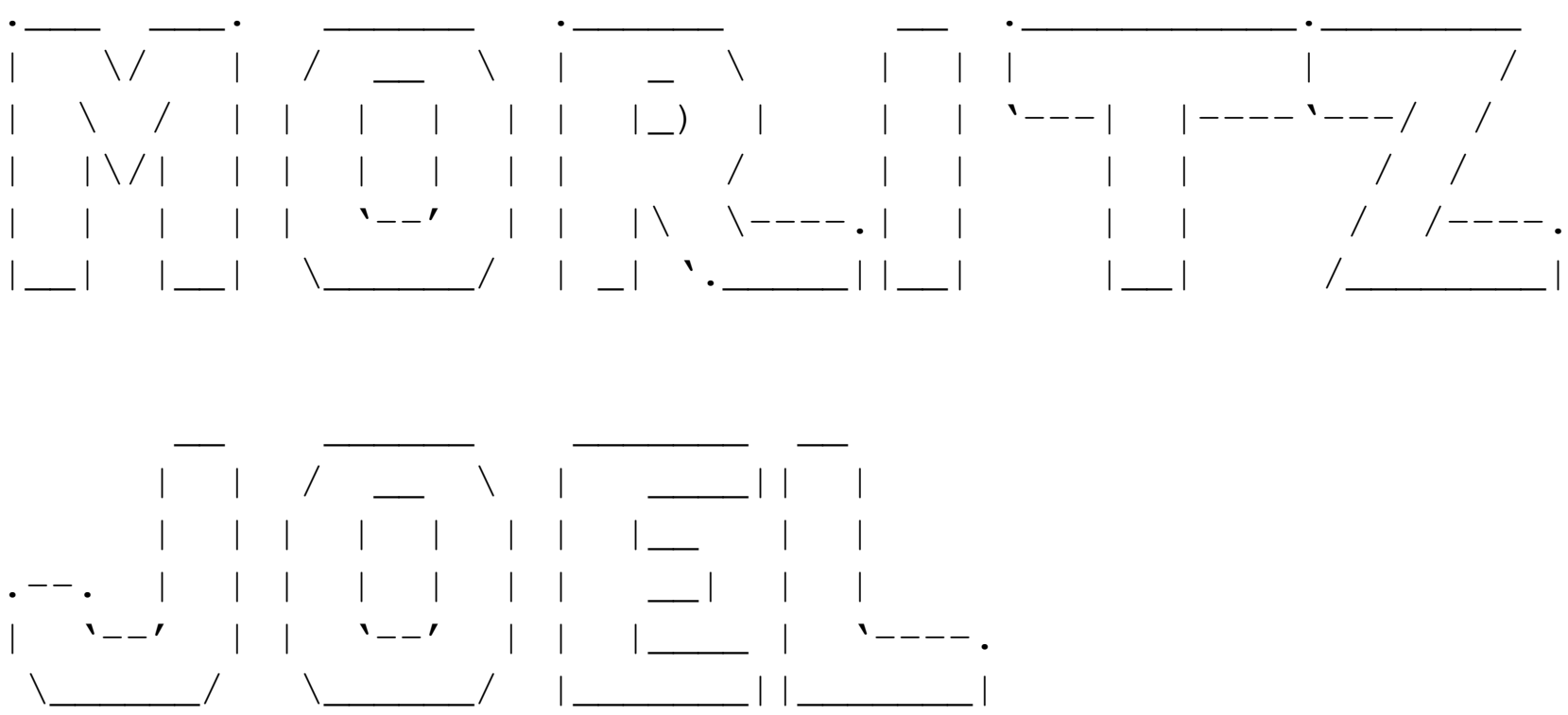
Using packages

```
from pyfiglet import figlet_format as asciiart

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print asciiart(t,font="starwars")
```



Using packages

```
from pyfiglet import *

teachers = ["moritz","joel","greg","joris"]

for t in teachers:
  print figlet_format(t,font="starwars")
```



Slicing

```
teachers = ["moritz","joel","greg","joris"]

print teachers[0]
print teachers[-1]
print teachers[:2]
print teachers[1:]
print teachers[::2]
print teachers[1::2]
```

```
moritz
joris
['moritz', 'joel']
['joel', 'greg', 'joris']
['moritz', 'greg']
['joel', 'joris']
```

Iterators

```
def fibonacci(a,b):
  yield a
  yield b
  n2, n1 = a, b
  while True:
    yield n1+n2
    n2, n1 = n1, n1+n2

for i in fibonacci(1,1):
  print i
  if i > 20: break
```

```
1
1
2
3
5
8
13
21
```

Scope

```
def simulate(a):
  return a**2

print simulate(3)
```

```
9
```

Scope

```
cache = {12: 144}

def simulate(a):
  if a in cache:
    return cache[a]
  else:
    print "working hard"
    return a**2

print simulate(3)
print simulate(12)
```

```
working hard
9
144
```

Scope

```
cache = {}

def simulate(a):
  if a in cache:
    return cache[a]
  else:
    print "working hard"
    cache[a] = result = a**2
    return result
```

Scope

```
print simulate(3)
print simulate(3)
cache = {}
print simulate(3)
```

```
working hard
9
9
working hard
9
```

Scope

```
cache = {}

def simulate(a,clear=False):
  if clear:
    cache = {}
  if a in cache:
    return cache[a]
  else:
    print "working hard"
    cache[a] = result = a**2
    return result
```

Scope

```
print simulate(3)
print simulate(3)
print simulate(3,clear=True)
```

```
      4    if clear:
      5      cache = {}
----> 6    if a in cache:
      7      return cache[a]
      8    else:

UnboundLocalError: local variable 'cache' referenced bef
```

Scope

```
cache = {}

def simulate(a,clear=False):
  global cache
  if clear:
    cache = {}
  if a in cache:
    return cache[a]
  else:
    print "working hard"
    cache[a] = result = a**2
    return result
```

Scope

```
print simulate(3)
print simulate(3)
print simulate(3,clear=True)
```

```
working hard
9
9
working hard
9
```

Scope

```
def simulate(a,clear=False,cache={}):
  if clear:
    cache = {}
  if a in cache:
    return cache[a]
  else:
    print "working hard"
    cache[a] = result = a**2
    return result
```

Scope

```
print simulate(3)
print simulate(3)
print simulate(3,clear=True)
```

```
working hard
9
9
working hard
9
```

Functions are objects too

```
def speaker(message):
  def temp(receiver):
    print "Hey", receiver, "!", message
  return temp

python_promoter = speaker("Time to learn Python")

python_promoter("Moritz")
python_promoter("audience")
```

```
Hey Moritz ! Time to learn Python
Hey audience ! Time to learn Python
```

Functions are objects too

```
def speaker(message):
  return lambda r: "Hey " + r + " ! " + message

python_promoter = speaker("Time to learn Python")

print python_promoter("Moritz")
print python_promoter("audience")
```

```
Hey Moritz ! Time to learn Python
Hey audience ! Time to learn Python
```

Classes

```
class Model(object):
  """ Represents a model """

  def __init__(self,labels):
    self.labels = labels

pendulum = Model(["theta","omega"])

print pendulum
```

```
<__main__.Model object at 0x0312A418>
```

Classes

```
type(pendulum)
```

```
__main__.Model
```

Classes

```
type(pendulum)
```

```
__main__.Model
```

```
pendulum?
```

```
Type:          Model
String form: <__main__.Model object at 0x031AC050>
Docstring:   Represents a model
```

Classes

```
class Model(object):
  """ Represents a model """

  def __init__(self,labels):
    self.labels = labels

  def __repr__(self):
    return "Model(" + str(self.labels)+ ")"

pendulum = Model(["theta","omega"])

print pendulum
```

```
Model(['theta', 'omega'])
```

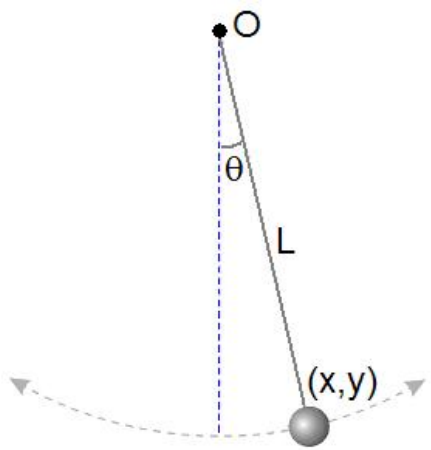
Classes

```
pendulum?
```

```
Type:          Model
String form:   Model(['theta', 'omega'])
Docstring:     Represents a model
```

Classes

```
class Pendulum(Model):
  def __init__(self,length=1.0):
    Model.__init__(self,["theta","omega"])
    self.length = length

  def describe(self):
    print "pendulum with length %d" % self.length

pendulum = Pendulum(2)
```



Classes

```
print pendulum
```

```
Model(['theta', 'omega'])
```

Classes

```
print pendulum
```

```
Model(['theta', 'omega'])
```

```
print pendulum.length
```

```
2
```

Classes

```
print pendulum
```

```
Model(['theta', 'omega'])
```

```
print pendulum.length
```

```
2
```

```
pendulum.length = 4

pendulum.describe()
```

```
pendulum with length 4
```

Getters and setters

```
class Pendulum(Model):
  def __init__(self,length=1.0):
    Model.__init__(self,["theta","omega"])
    self._length = length

  def getLength(self):
    return self._length

  def setLength(self, value):
    self._length = value

pendulum = Pendulum(2)
```

Getters and setters

```
pendulum.<tab>
```

```
pendulum.getLength
pendulum.labels
pendulum.setLength
```

Getters and setters

```
pendulum.setLength(5)
print pendulum.getLength()
```

```
5
```

Getters and setters

```
pendulum.setLength("spam")
print pendulum.getLength()
```

```
spam
```

Getters and setters

```
pendulum.se
print pendu
```

```
spam
```

Getters and setters

```
class Pendulum(Model):
  def __init__(self,length=1.0):
    Model.__init__(self,["theta","omega"])
    self._length = length

  def getLength(self):
    return self._length

  def setLength(self, value):
    if isinstance(value,int):
      self._length = value
    else:
      raise Exception("Expected number")
```

Getters and setters

```
pendulum = Pendulum(2)
pendulum.setLength("spam")
```

```
Exception: Expected number
```

Getters and setters

```
def setLength(self, value):
  if isinstance(value,int):
    self._length = value
  else:
    raise Exception("Expected number")
```

This is unpythonic

Getters and setters

```
def setLength(self, value):
  try:
    self._length = int(value)
  except:
    raise Exception("Expected number")
```

This is pythonic

Getters and setters

```
def setLength(self, value):
  try:
    self._length = int(value)
  except:
    raise Exception('Expected Number')
```

EAFP: Easier to ask for forgiveness than permission

This is pythonic

Getters and setters

```
pendulum.setLength(5)
```

Getters and setters

```
pendulum.setLength(5)
```

```
pendulum.setLength('5')
```

Getters and setters

```
pendulum.setLength(5)
```

```
pendulum.setLength('5')
```

```
pendulum.setLength('spam')
```

```
Exception: Expected number
```

Getters and setters

```
class Pendulum(Model):
  def __init__(self,length=1.0):
    Model.__init__(self,["theta","omega"])
    self.length = length

  @property
  def length(self):
    return self._length

  @length.setter
  def length(self, value):
    try:
      self._length = int(value)
    except:
      raise Exception("Expected number")

pendulum = Pendulum(2)
```

Getters and setters

```
pendulum.<tab>
```

```
pendulum.labels     pendulum.length
```

Getters and setters

```
pendulum.<tab>
```

```
pendulum.labels     pendulum.length
```

```
pendulum.length = "5"
print pendulum.length
```

```
5
```

Getters and setters

```
pendulum.<tab>
```

```
pendulum.labels     pendulum.length
```

```
pendulum.length = "5"
print pendulum.length
```

```
5
```

```
pendulum.length = "spam"
```

```
Exception: Expected number
```

Code reuse

Code Listing 1: models.py

```
class Model(object):
    """ Represents a model """

    ...

class Pendulum(Model):

    ...
```

```
from models import Pendulum

pendulum = Pendulum(3)
```

Code reuse

Code Listing 2: models.py

```
class Model(object):
    """ Represents a

    ...

class Pendulum Mode

    ...
```


```
from models import Pendulum

pendulum = Pendulum(3)
```

Code reuse

Code Listing 3: models.py

```
class Model(object):
  """ Represents a model """

  ...

class Pendulum(Model):

  ...

if __name__ == "__main__":
  p =  Pendulum()
  p.describe()
```

Code reuse

```
$ python models.py
```

```
pendulum with length 1
```

Pickling

```
import pickle

teachers = ["moritz","joel","greg","joris"]
namelengths = [len(p) for p in teachers]

results = (teachers,namelengths)
pickle.dump(results,file('results.pkl','w'))
```

Pickling

```
import pickle

teachers = ["moritz","joel","greg","joris"]
namelengths = [len(p) for p in teachers]

results = (teachers,namelengths)
pickle.dump(results,file('results.pkl','w'))
```

```
import pickle

teachers,namelengths =
  pickle.load(file('results.pkl','r'))
print teachers, namelengths
```

```
['moritz', 'joel', 'greg', 'joris'] [6, 4, 4, 5]
```

Command line arguments

Code Listing 4: simulator.py

```
import numpy as np
import sys

N = int(sys.argv[1])
items = sys.argv[2:]

for i in range(N):
  n = len(items)
  print items[np.random.randint(n)]
```

Command line arguments

Code Listing 5: simulator.py

```
import numpy as np
import sys

N = int(sys.argv[1])
items = sys.argv[2:]

for i in range(N):
  n = len(items)
  print items[np.random.randint(n)]
```

```
$ python simulator.py 3 spam eggs
```

```
eggs
spam
spam
```

Command line arguments

```
$ python simulator.py spam eggs 3
```

```
ValueError                                Traceback
C:\Users\jg\hello.py in <module>()
      2 import sys
      3
----> 4 N = int(sys.argv[1])
      5 items = sys.argv[2:]
      6

ValueError: invalid literal for int() with base 10: 'spa
```

Command line arguments

Code Listing 6: simulator.py

```
try:
  N = int(sys.argv[1])
except:
  raise Exception("""Oops. Expecting a number but
        you supplied me with '%s'.
        """ % sys.argv[1])
```

```
Exception: Oops. Expecting a number but
        you supplied me with 'spam'.
```

Command line arguments

Code Listing 7: simulator.py

```
from argparse import *
import numpy as np

p = ArgumentParser(
      description="Simulate drawing from a collection")
p.add_argument('--N', type=int, default=10,
   help="The number of draws")
p.add_argument('items', type=str, nargs='+',
   metavar='item',  help='the items to draw from')
p.add_argument('--special', action='store_true')

args = p.parse_args()

for i in range(args.N):
  n = len(args.items)
  print args.items[np.random.randint(n)]
```

Command line arguments

```
$  python simulator.py
```

```
usage: hello.py [-h] [--N N] [--special] item [item ...]
hello.py: error: too few arguments
```

Command line arguments

```
$ python simulator.py -h
```

```
usage: hello.py [-h] [--N N] [--special] item [item ...]

Simulate drawing from a collection

positional arguments:
  item         the items to draw from

optional arguments:
  -h, --help   show this help message and exit
  --N N        The number of draws
  --special
```

Command line arguments

```
$  python  simulator.py --N 3 spamm eggs
```

```
spamm
eggs
eggs
```

Interacting with the shell

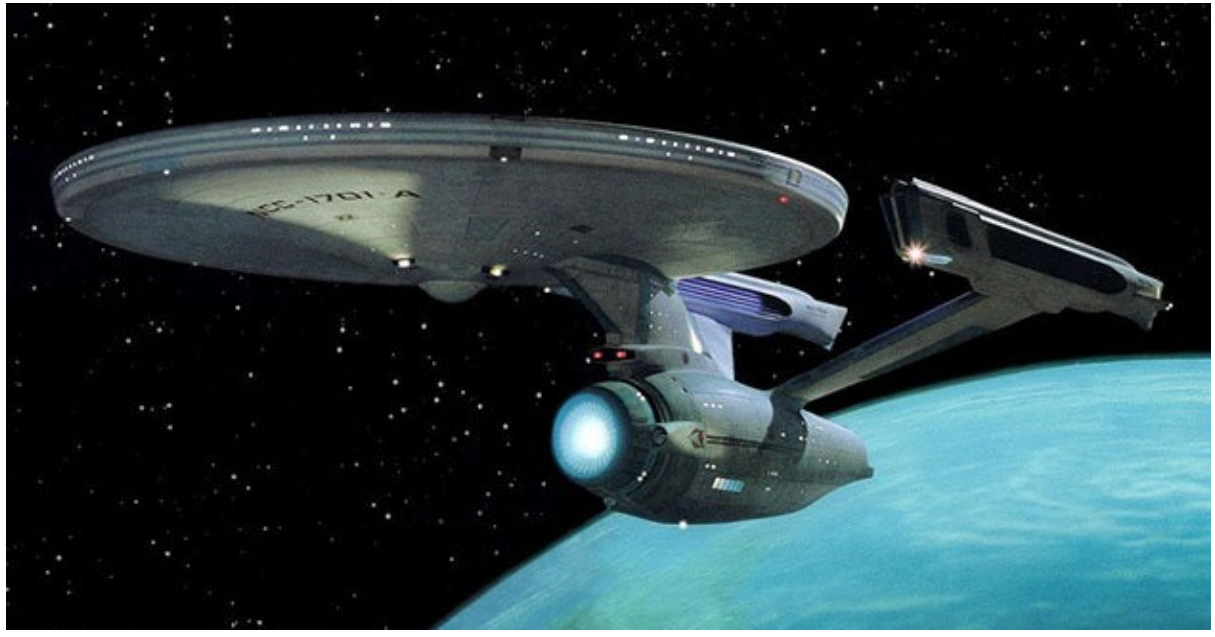
```
import subprocess

items = ["spam", "eggs"]

N = 3
p = subprocess.Popen(
  ["python","simulator.py","--N", "%d" % N] + items,
  stdout=subprocess.PIPE, stderr=subprocess.PIPE)

stdout, stderr = p.communicate()
print stdout
```

```
eggs
spam
eggs
```

Interacting with the shell

Conclusion

This should be enough background to explore the Python universe



Happy coding!