
Python Supernova
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December 2012

How to Learn a New Language?

```
learnLanguage(L) :-
        findExample(L, E),
        imitateExample(E),
        fail.
learnLanguage(L) :-
        acquireManual(L, M),
        readManual(M),
        fail.
learnLanguage(L) :-
        findYouTubeVideo(L, V),
        viewVideo(V),
        fail.
learnLanguage(L) :-
        askForum(L, P),
        viewAnswer(P),
        fail.
learnLanguage(L) :-
        tryToTeach(L).
```

How to Jump Start Learning a Language

- **Imitate** existing examples.
- Try to align them with **concepts you already know** from other languages.
- There are 1000's of languages, but probably fewer than 100 concepts.
- Try to "see through" the syntax to the core.
- Determine what data types are available.
- Try to discern what the underlying data and control models are.

How to Jump Start Learning a Language

Concept	Language
Open lists	Racket, Prolog
Function	Racket
Anonymous function	Racket
Object	Java
Method	Java
Pattern matching	Prolog
Predicate logic	Prolog, SQL
2D matrices	Matlab
Infinite lists	Haskell
Iterators	C++, Java
List comprehensions	KRC, Miranda, Haskell
Type inference	ML

High vs. Low Ceremony Languages

- **High Ceremony** (classes, header files, …)

  Java, C, C++, Ada, Fortran, …

- **Low Ceremony**:

  Racket, Prolog, Matlab, Python, Ruby, Javascript, Groovy, Lua, Basic, …

- High ceremony tend to require a compiler, whereas low ceremony sometimes just use an interpreter, a REPL.

- **"Scripting" languages** tend to be low ceremony. They often include useful built-ins for **interacting with the operating system**.

Static vs. Dynamic Typing

- ***Static*** vs. ***Dynamic*** refers to whether a variable can refer only one type of thing (int, String, function, …) or multiple types.

- Racket and Prolog are examples of dynamic languages.

- Java is (mostly) statically typed, although using Object as a type allows dynamic as well.

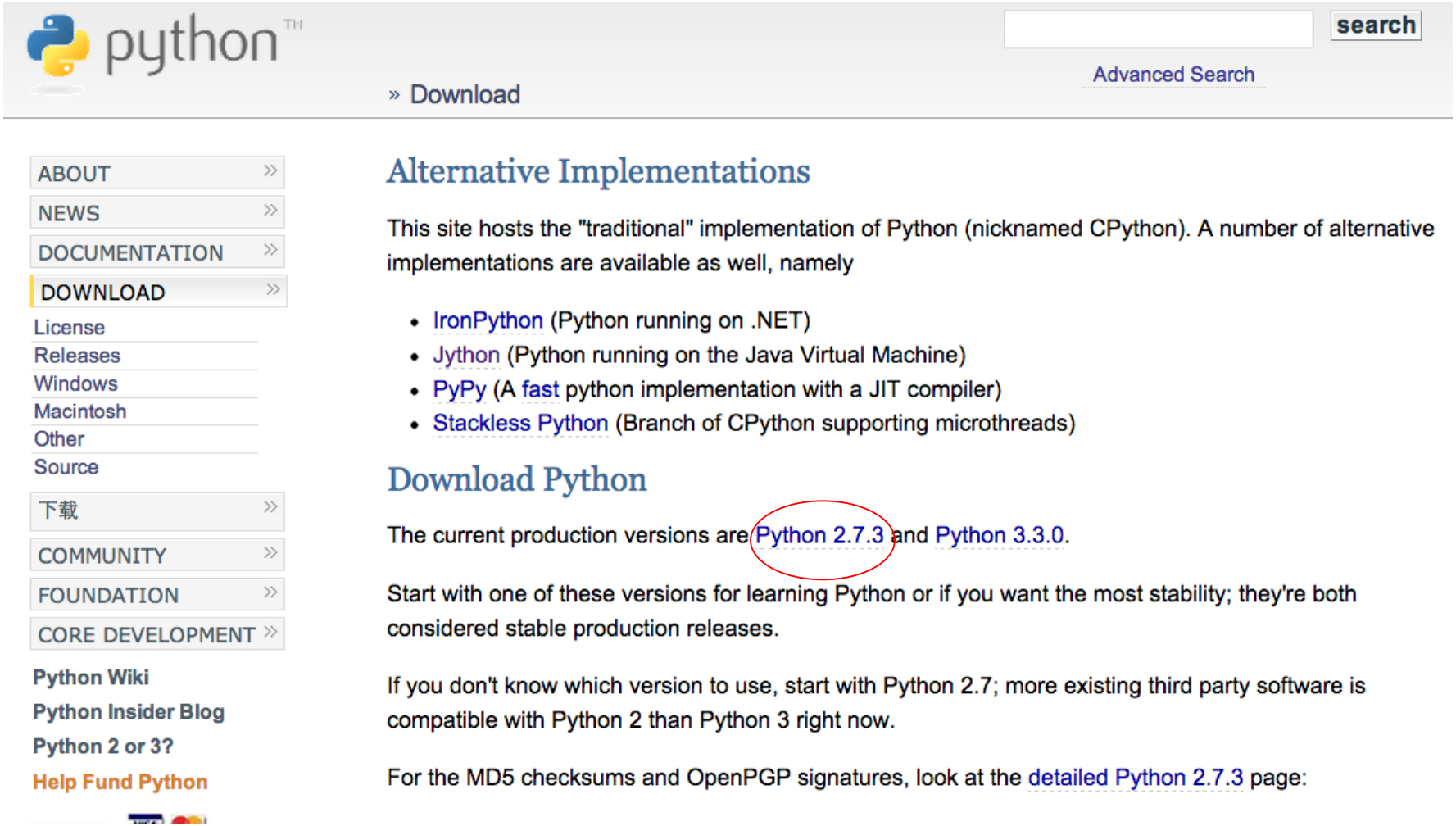
- ML, Haskell, Scala, and *go* are statically typed.

Type Safety

- Static types allow the compiler to **check for type errors in advance**.
- With dynamic types, errors might not be detected until the program runs.
- But static types often require more ceremony.
- Dynamic types may be preferred for prototyping, static types for production.
- Static typing tends to go with higher ceremony.

Python

Download python here: http://www.python.org/



Python Discontinuity

- Python 2.7.x
- Python 3.3.x

  apparently are different enough that most libraries run only on the first version.

Python Characteristics

- Python is an imperative language with some support for objects, modules, and functional programming.
- Dynamically typed
- Interpreted, REPL
- Scripting

Python REPL

execution command

```
$ python
Python 2.7.3 (v2.7.3:70274d53c1dd, Apr  9 2012, 20:52:43)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

banner

prompt

Python Script

- Scripts run as OS commands on the command line.
- They identify the location of the Python interpreter.

Definition of pi.py:

location of Python executable on my machine

```
#!/Library/Frameworks/Python.framework/Versions/2.7/bin/python
from math import pi
print(pi)
```

Example use (in Unix):

```
$ ./pi.py
3.14159265359
```

Script with Command-Line Arguments

- sys.argv identifies the items on the command line, starting with the command itself

contents of sort.py

```
#!/Library/Frameworks/Python.framework/Versions/2.7/bin/python
import sys
args = sys.argv
args.pop(0)
args.sort()

for x in args:
    print(x)
```

Example Use:

```
$ ./sort.py 5 4 2 1 3
1
2
3
4
5
```

Python Strings

- Use matching single or double quotes
- Evaluate for value

```
>>> 'foo bar'
'foo bar’

>>> "foo bar"
'foo bar'
```

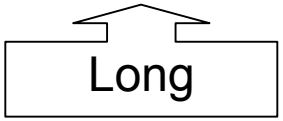
- Ways to embed quotes in string:

```
>>> "doesn't"
"doesn't"
>>> 'doesn"t'
'doesn"t'
>>> 'doesn\'t'
"doesn't"
>>> "doesn\"t"
'doesn"t'
```

Assignment and Recall

```
>>> z = "abc"
>>> z
'abc'

>>> x = 12371289371827398172839172837912738127381973
>>> x
12371289371827398172839172837912738127381973L
```




```
>>> y = 34.567e13
>>> y
345670000000000.0

>>> x*y
4.2763835971595765e+57
```

Python Data Types

- Integers (arbitrary precision)
- Float (double precision)
- Complex (use .real and .imag to get components)
- Strings
- Lists
- Tuples
- Dictionaries
- Objects

Lists

- Lists are mutable

- Lists are rendered comma-separated, in square brackets.

```
>>> ['This', 'is', 'a', 'list.']
['This', 'is', 'a', 'list.']
```

- Indexing starts at 0, and also uses square brackets.

```
>>> ['This', 'is', 'a', 'list.'][2]
'a'
```

Nested Lists

- Lists can be nested, as in Racket and Prolog:

```
>>> ['This', ['is', ['a', ['nested', 'list.']]]]
['This', ['is', ['a', ['nested', 'list.']]]]
```

Lists are Mutable

Indexing starts at 0

```
>>> L = [10, 20, 30, 40]

>>> L[0]
10
>>> L[1]
20

>>> L[3] = 42
>>> L
[10, 20, 30, 42]
```

Negative Indexing

```
>>> L
[10, 20, 30, 42]

>>> L[-1]
42

>>> L[-2]
30

>>> L[-3]
20
```

List Operations

- **len(list)**

  Returns the length of the list.

- **list.append(x)**

  Add an item to the end of the list. This is like **cons** in Racket, except on the tail of the list, instead of the head.

- **list.extend(L)**

  Extend the list by appending all the items in the given list. This is like **append** in OpenList.

- **list.insert(i, x)**

  Insert an item at a given position. The first argument is the index of the element before which to insert, so a.insert(0, x) inserts at the front of the list, and a.insert(len(a), x) is equivalent to a.append(x).

- **list.remove(x)**

  Remove the first item from the list whose value is x.
  It is an error if there is no such item.

More List Operations

- **list.pop(i)**

  Remove the item at the given position in the list, and return it.
  If no index is specified, a.pop() removes and returns the last item in the list.

- **list.index(x)**

  Return the index in the list of the first item whose value is x. It is an error if there is no such item.

- **list.count(x)**

  Return the number of times x appears in the list.

- **list.sort()**

  Sort the items of the list, **in place**.

- **list.reverse()**

  Reverse the elements of the list, **in place**.

Tuples

- Tuples are immutable
- Tuples are rendered as comma-separated, with regular parentheses.

```
>>> type(['a', 'b', 'c'])
<type 'list'>

>>> type(('a', 'b', 'c'))
<type 'tuple'>
>
```

Tuples and Lists can be Interconverted

```
>>> [x,y,z]=(1,2,3)
>>> [x,y,z]
[1, 2, 3]

>>> (a, b, c) = [x, y, z]
>>> (a, b, c)
(1, 2, 3)
```

Dictionaries

- Curly braces { } represent the **dictionary** data type.
- They are not used for code organization, as in Java and C.
- A **dictionary** is a hashtable, and can serve a role similar to an association list.
- Square brackets [ ] are used to access elements of a dictionary

Dictionary Example

```
>>> my_dictionary = {'a':10, 'b':20, 'c':30}

>>> my_dictionary
{'a': 10, 'c': 30, 'b': 20}

>>> my_dictionary['b']
20
```

Dictionaries are Mutable

```
>>> my_dictionary
{'a': 10, 'c': 30, 'b': 20}

>>> my_dictionary['b'] = 42

>>> my_dictionary
{'a': 10, 'c': 30, 'b': 42}
```

Global Variables

- Assignments shown bind variables in the global namespace

- You can find out what variables are bound by the built-in globals(), which returns a **dictionary**

```
>>> globals()
{'a': 'foo bar', 'hello': <module 'hello' from 'hello.py'>,
'x': 12371289371827398172839172837912738127381973L,
'y': 345670000000000.0,
'z': 'abc', …}
```

Indentation

- Indentation is mandatory in Python control structures.
- It replaces braces in Java.
- In the REPL, indent 4 spaces after …,

  which tell you that the command is continuing.
- Colons after the if part and else part are required.

```
>>> if x > 4/3:
...     print('yes')
... else:
...     print('no')
...
yes
```

elif = else + if

```
>>> if x < 4/3:
...     print('yes')
... elif x == 0:
...     print('maybe')
... else:
...     print('no')
...
no
```

while

```
>>> i = 1
>>> while i < 10:
...     print(i)
...     i = i + 1
...
1
2
3
4
5
6
7
8
9
```

for

- *for* iterates over a list

```
>>> for color in ['red', 'green', 'blue']:
...     print(color)
...
red
green
blue
```

range

- range makes a list, e.g. to be used with for

```
>>> range(1, 10)
[1, 2, 3, 4, 5, 6, 7, 8, 9]

>>> range(2, 11, 2)
[2, 4, 6, 8, 10]

>>> range(11)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

for in range

```
>>> for x in range(0, 10):
...     print(x)
...
0
1
2
3
4
5
6
7
8
9
>>> x
9
```

List Comprehensions

- A clever idea that came from functional languages (KRC & Miranda by David Turner, University of Kent)

- Recall set notation from math:
  {f(x) | … some property of x …}

- Analogously, a list can be constructed
  [f(x) … some iterator of x …]

- Advantage: More declarative

- Example:

  [x*x for x in range(1, 11)]

  is [1, 4, 9, 16, 25, 36, 49, 64, 81, 100]

List Comprehension Examples

```
>>> [x*x for x in range(1, 11)]
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]

>>> def mymap(f, L):
...     return [f(x) for x in L]

>>> mymap(lambda x: x*x, range(1, 11))
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]

>>> [(x, y) for x in [1, 2, 3] for y in ['a', 'b', 'c']]
[(1, 'a'), (1, 'b'), (1, 'c'), (2, 'a'), (2, 'b'), (2, 'c'), (3, 'a'), (3, 'b'), (3, 'c')]

>>> def cartesian_product(L, M):
...     [(x, y) for x in L for y in M]
...     return [(x, y) for x in L for y in M]

>>> cartesian_product(range(1, 4), ['a', 'b', 'c'])
[(1, 'a'), (1, 'b'), (1, 'c'), (2, 'a'), (2, 'b'), (2, 'c'), (3, 'a'), (3, 'b'), (3, 'c')]
```

Using *if* in List Comprehension

- See example under Class Definition

Function/Procedure definition

```
>>> def fac(n):
...     if n < 2:
...         return 1
...     return n*fac(n-1)
...

>>> fac
<function fac at 0x100499c80>

>>> fac(5)
120
```

Function Definitions and Docstrings

Finally, a use for triple double quotes

Note that indentation is required, not optional.

```
def add(x, y):
    """Return the sum of x and y."""
    return x + y
```

The docstring is the first string literal to appear in an object's definition.

object's docstring shows up when you use the built-in "help" function:

```
>>> help(add)
Help on function add in module __main__:

add(x, y)
    Return the sum of x and y.
```

You can look up any object's docstring via the `__doc__` attribute:

```
>>> print add.__doc__
Return the sum of x and y.
```

Anonymous Functions

```
>>> square = lambda x: x*x

>>> square
<function <lambda> at 0x100499d70>

>>> square(5)
25

>>> z = 100
>>> scale = lambda x: x*z
>>> scale
<function <lambda> at 0x100499cf8>
>>> scale(5)
500

>>> z = 10
>>> scale(5)
50
```

Static Binding

```
>>> def foo(x):
...     z = 99
...     return z * x
...

>>> foo(10)
990

>>> z = 90

>>> foo(10)
990
```

Higher Order Functions

```
>>> def compose(f, g):
...     return lambda x: f(g(x))
...

>>> compose(scale, square)
<function <lambda> at 0x10049f230>

>>> compose(scale, square)(5)
250
```

map/reduce (like foldl)

```
>>> map
<built-in function map>

>>> map(square, range(1, 11))
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]

>>> reduce(lambda x, y: x+y, [1, 2, 3, 4, 5])
15
```

Must use lambda, not plain +.

Modules: Code Organization

- Modules are identified by their file name.

```
$ cat hello.py
def say_hello():
    print 'hello'
    return

$ python

>>> import hello
>>> hello.say_hello()
hello
```

contents of hello.py

Locating Modules

When you import a module, the Python interpreter searches for the module in the following sequences:

- The current directory.
- If the module isn't found, Python then searches each directory in the shell variable PYTHONPATH.
- If all else fails, Python checks the default path. On UNIX, this default path is normally /usr/local/lib/python/.

The module search path is stored in the system module sys as the **sys.path** variable. The sys.path variable contains the current directory, PYTHONPATH, and the installation-dependent default.

The *PYTHONPATH* Variable:

The PYTHONPATH is an environment variable, consisting of a list of directories. The syntax of PYTHONPATH is the same as that of the shell variable PATH.

Here is a typical PYTHONPATH from a Windows system:

```
set PYTHONPATH=c:\python20\lib;
```

And here is a typical PYTHONPATH from a UNIX system:

```
set PYTHONPATH=/usr/local/lib/python
```

Defining Classes

```
#!python

class Student:

   instances = []                                # class (static) variable

   def __init__(self, name, graduation_year):    # constructor/initializer
      """ create an instance of Student """
      self.name = name                           # instance variable
      self.graduation_year = graduation_year     # instance variable
      self.credits = 0                           # instance variable
      Student.instances.append(self)             # using class variable

   def display(self):                            # method
      """ display a Student """
      print "Name :", self.name,                          \
             ", Graduation_Year:", self.graduation_year, \
             ", Credits:", self.credits


   def addCredit(self, units):                   # method
      """ add units to this Student's credits """
      self.credits += units

   def getCredits(self):                         # method
      """ return the credits of this Student """
      return self.credits

   def getCount(self):                           # method using class variable
     """ get the total number of Students """
     return len(Student.instances)

   def getCohort(self):                          # method using class variable
     """ get the cohort of this Student as a list """
     return [student for student in Student.instances
                     if student.graduation_year == self.graduation_year]
```

Creating and Using Objects

```
#!python

from student import Student

# Create 4 students

alice  = Student("Alice", 2015)
bob    = Student("Bob", 2015)
carol  = Student("Carol", 2016)
dave   = Student("Dave", 2016)

alice.display()

print "Total students:", alice.getCount()


print "Bob's cohort:"

for student in bob.getCohort():
    student.display()


print "Dave's cohort:"

for student in dave.getCohort():
    student.display()
```

Libraries

- Pygame - Game Development
- SciPy - Scientific computing
- NumPy - Numeric computing
- Pybrain - Machine Learning
- Django - Web Development

Django Reinhardt

Mashups

- jython = Python interface to Java
- Cython = C extension to Python
- PyScheme = Scheme (Racket's parent) in Python
- PySWIP = Python + SWI Prolog
- PyPHP = Python + PHP
- PySqlite = Python + SQL
- Pyrex = glassware

PyScheme

```
$ python pyscheme/scheme.py
Welcome to PyScheme!  Type: (QUIT) to quit.

[PyScheme] >>> (define (factorial x)
[.....1)] >>>    (if (= x 0)
[.....2)] >>>        1
[.....2)] >>>        (* x (factorial (- x 1)))))
OK
[PyScheme] >>> (factorial 5)
120
[PyScheme] >>> (define (map f l)
[.....1)] >>>    (cond ((null? l) '())
[.....2)] >>>          (else (cons (f (car l))
[.....4)] >>>                      (map f (cdr l))))))
OK
[PyScheme] >>> (map factorial '(1 2 3 4 5 6))
[1, 2, 6, 24, 120, 720]
[PyScheme] >>> (define foo 'unquote)
OK
[PyScheme] >>> '(hey look I support ,foo)
['HEY', 'LOOK', 'I', 'SUPPORT', 'UNQUOTE']

;; PyScheme 1.0 stuff:
[PyScheme] >>>  ((lambda (x) (list x (list (quote quote) x)))
[.....1)] >>>   (quote (lambda (x) (list x (list (quote quote) x)))))
((lambda (x) (list x (list (quote quote) x))) (quote (lambda (x) (list x (list (quote quote) x)))))
[PyScheme] >>> (append '(1 2 3) (list 4 5 '(6)) 7)
(1 2 3 4 5 (6) . 7)
[PyScheme] >>> (quit)
bye
```