

Beginners Python Course

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1 Introduction

Python is a general purpose interpretive language. Unlike C, python is not compiled but is instead executed at runtime. This gives python a great deal of flexibility at the expense of speed. Python is widely used in scientific computing, particularly as a much more user friendly interface to numerical solvers typically written in C/Fortran.

I appologies in advance for the blatent anti-windows bias in this document. However if you do decide to base your operating system on something other than unix you deserve everything you get.

1.0.1 Strengths:

- Interpreted, can run individual commands in consol - very easy to trial code segments.
- Alot of very good third party libraries, e.g. numpy, scipy,matplotlib. Many of these are written in C so are fast.
- Readability
- Comparitively recent language, so objects, lists and other features of a "Modern" Programming language haven't been tact on haphazardly.
- Well documented, far less inaccurate information than other languges (*C pointers*)

1.0.2 Weaknesses:

- Interpreted, significantly slower than compiled languages
- Is very reliant on third party libraries to be truely useful
- Use of indentation for code blocks, aids readability but inconsitency can lead to portability issues.
- alot of changes between python 2 and 3 which are fairly incompatible.

1.1 General Things to Note:

Python is an interpreted language and does not need to be compiled before use. This means that python can be run in a terminal or other programming enviroment (e.g. ipython), and commands can be executed line by line in a mannor similar to Matlab. Like Matlab python scripts are not compiled, rather python reads each line in turn and executes it. This has the great advantage that new code can be prototyped, written and run in much less time than for a compiled language. Also python makes a great scripting

language and can be used to quickly open and modify large files without having to write and execute a program. However an interpreted code comes at a cost, and is much slower than compiled codes.

The fact that python executes each line in turn is a significant aid to debugging as when your code inevitably crashes it typically exits on the line which caused the crash. Python also deals with all the memory allocation in the code so memory leaks don't (read shouldn't, you can probably do it if you're sufficiently determined) happen in python.

Python uses indentation to denote code blocks in a manner similar to how C makes use of curly braces { }. This is a great aid to the readability of the code as it forces code to be properly indented and avoids the clutter of have {, } or words such as **do** and **done** littered throughout the code. However it does have one major issue in that it is very inconsistent, with any number of whitespace characters (tab space etc) usable for indentation. It has unfortunately become not uncommon for programmers on backwards operating systems (i.e. windows) to use tabs for indentation. This is very bad practice and completely ruins the portability of the code, as tab is not consistently defined between operating systems and will normally get converted to an inconsistent number of whitespace characters if the code is run on linux/mac.

1.2 The Golden Rule!

The Golden Rule of Python is to do as little computational work in python as possible by making use of third party libraries.

Particularly For loops are a bad idea! A lot of code that you can write with for loops can also be done using third party libraries. In many cases all the third party library will do is execute exactly the same loop code (barring possible optimisation) as you would have done. However the major third party libraries are written in C so the code will execute much faster.

2 Syntax and Language

The following is a reference to python's language and Syntax. Python is actually well documented and has a central documentation here <https://docs.python.org/3/>. And of course stack overflow is your eternal saviour. It's important to note that python has changed significantly between version 2 and 3 and in a way that basically breaks everything between the versions. Python 3 is annoyingly more restrictive than 2 but it is more consistent. This section is not meant to be exhaustive, that's what the main documentation is for, but to contain enough to get started.

I have also decided to keep more advanced commands such as try/except and classes separate from this section

2.1 General Syntax

2.2 Basic Language Reference

2.2.1 Comments

```
# this is a comment in python

'''
This is a multiline comment in python
it can also be used to define multiline
string and is quite good for documentation
'''
```

2.3 Print Statement

```
a_variable = "to be printed"

# python 2 print syntax
print a_variable

#python 3 print syntax
print(a_variable)

# all types in python can be printed,
# however what python actually prints
# is very type dependent.
```

2.3.1 If statement

```
# if statement for python, here bool
# is a boolean variable or an integer
# 1 or 0. The brackets are entirely optional

if (bool):
    print "true"

# also can use logical conditionals

if (a == b):
    print "true"
```

2.3.2 Loops

#for loop

```
For i in [1,2,3]:  
    print i
```

while loop

```
while true:  
    print 1
```

2.3.3 Functions

define a function

```
def foo(a,b):  
    # note the indent  
    # I also do not need to tell python what  
    # type the function takes/returns as this  
    # is determined at runtime  
    return a + b
```

2.3.4 Import statement

#the import statement for importing libraries/functions

```
# imports the whole library  
# call members of the library by prefixing with the name  
# of the library e.g.  
# numpy.foo()
```

```
import numpy
```

```
# imports the whole library but changes the prefix to np  
# so a member of the library can be called by:  
# np.foo()
```

```
import numpy as np
```

```
# import a single member of the library
```

```
from numpy import foo
```

```
# this can no be called using:
```

```
# foo()

# note these are used to import your own libraries
# so the command:

import mylibrary

# will look for mylibrary.py in the local directory and
# run this, thus enabling all the functions/variables
# in mylibrary.py to be used
```

2.3.5 Basic Data Types

```
# The type of a python variable is determined at runtime
# based on what is assigned to it.

# declare a string
var = "a string"

# floating point number
var = 1.0

#integer
var = 1

# warning it is a common mistake in python to do
# the following:

var = 1/2

# this is not 1/2! As 1 and 2 are integers, integer division is
# performed, the value of var is 0
# to assign a value of a half floats must be used:

var = 1.0/2.0

# a list, this is similar to an array, except that it is extendable
# i.e. is not of a fixed length

var = [1,2,3]
```

2.3.6 File I/O

```
# to open a file for reading in the local directory
# called read.txt

f = open("read.txt","r")

# read a line
line = f.readline()

# read entire file
data = f.read()

# open file for writing

g = open("write.txt","w")

# write to file
g.write(data)

# add a new line
g.write("a new line\n")

# you should close files when they are do
# as python doesn't have a compiler to tell
# it when they are no longer in use
f.close()
g.close()
```

2.4 Boolean Logic and Comparison Operators

Python Boolean Logic and Comparisons are the same as C.

<code>a == b</code>	a equals b
<code>a != b</code>	a not equal to b
<code>a < b</code>	a less than b
<code>a > b</code>	a greater than b
<code>a <= b</code>	a less than or equal to
<code>a >= b</code>	a greater than or equal to
<code>not a</code>	boolean not operator
<code>a and b</code>	boolean and operator
<code>a or b</code>	boolean or operator
<code>a is b</code>	checks if a and b are the same object
<code>a is not b</code>	checks if a and b are not the same object
<code>a in b</code>	checks if a is a member of b, e.g. if it is an element in a list
<code>a not in b</code>	checks if a is not a member of b

2.5 Arithmetic

Native python has both integer and floating point arithmetic built in. It also has sequence arithmetic which is used for concatenating strings and certain array like structures such as lists. Python has an operator precedence which is the normal brackets,power,multiplication,addition ordering.

2.5.1 Integer Arithmetic

<code>a + b</code>	adds two integers
<code>a - b</code>	subtracts two integers
<code>a / b</code>	integer division, a divided by b and neglects the remainder
<code>a % b</code>	modulus, divides a by b and returns the remainder
<code>a * b</code>	multiplies two integers
<code>a ** b</code>	raises a to the power of b

2.5.2 Floating Point Arithmetic

The operators for floating point arithmetic are the same as for integer arithmetic except that they operate on floats. The exceptions are:

2.5.3 Integer Arithmetic

<code>a / b</code>	floating point division, a divided by b including remainder
<code>a // b</code>	floor division, this acts like integer division and divided a by b neglecting the remainder

Python also has an increment operator similar to C's "++". Performing `a = a + b` can be done using the +=assignment operator by: `a += b`. All the above operators have similar assignment operators. So `*`, `**`, `/` = etc can be used to multiple/raise to the power/divide the existing value of the variable by a new value.

2.5.4 Sequence Arithmetic

Python has arithmetic operators which act on sequences. These are not the same as array operations! Native python does not have an array structure on which elementwise arithmetic can be performed like Fortran or Matlab. Instead it has sequences such as lists `[1,2,3]` and strings `"abc"`. Note that python treats strings as lists of characters so `"abc"` is treated similarly to `["a","b","c"]` (Although a string is not regarded as a list type).

`a + b` concatenates `a` and `b`, with `b` following on from `a`. So `[1,2]`
 + `[3]` becomes `[1,2,3]`
`a*n` Where `a` is a sequence and `n` an integer. Concatenates `n`
 copies of `a` into a single sequence. so `[1,2]*2` becomes `[1,2,1,2]`

3 Third Party Libraries

The key to good python code is the use of libraries. Most things that you want to do in python have already been implemented in a library and are normally much faster than the equivalent code in python.

3.0.5 Inbuilt libraries

- `math` : basic maths library containing definitions of `pi`, `sin` etc. It's rare for this to actually be useful as all of it is defined in `numpy`
- `os` : extensive library for interacting with the operating system, e.g. open/writing to files, looping over files in a directory etc.
- `sys` : for interacting with the system environment and for passing your code command line arguments. This is actually part of the `os` library but, unless you are dealing with file paths, is probably all you need.

3.0.6 Important third party libraries

- `numpy` : the main numerical library in python. Contains the definitions for arrays, matrices complex numbers and many basic mathematical functions/operations. Also includes good support for reading from/writing to delimited files
- `scipy` : an extensive library for scientific computations. Includes functions for statistics, ode solvers, least squares inversion/curve fitting and many special functions.
- `matplotlib` : the main plotting library for python. heavily influenced Matlab plots.

- pylab : a cut down version of matplotlib for when you want to plot the data but don't really need that much control over the presentation. (I use it alot as I am lazy).
- PyQt and PyGTK : for when you have to write a GUI

4 Sequences (Array Structures) in Python

5 Numpy

I have devoted an entire section on numpy due to it's utility. Correct use of numpy will make most of what was covered in Section 4 obsolete.