**PYTHON PROGRAMMING**

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**Introduction To Python Programming** Instructed by Avinash Jain <https://www.udemy.com/pythonforbeginnersintro/> (enrolled 8/10/15) (Python v3.4.3 downloaded 8/10/15) <http://docs.python.org/3.4/tutorial/>

**COMPLETE PYTHON BOOTCAMP** Instructed by Jose Portilla <https://www.udemy.com/complete-python-bootcamp/learn/#/> (enrolled 1/1/16)

**Jupyter notebooks:** <http://nbviewer.ipython.org/github/jmportilla/Complete-Python-Bootcamp/tree/master/>

**Using Jupyter notebooks:**

Jupyter is an IDE that facilitates writing code cell-by-cell, running cells individually, reordering, interrupting kernals, etc. Additionally, it acts like a cloud in that you can store/share/download other users’ notebooks

Shift+Enter will run a cell (shift+enter on a blank cell will clear any residual output in the cell)

Tab will show a pop-up of the methods on an object

Shift+Tab will show help pop-up for docstring

Cells can be assigned as code (obvious), Markdown (for entering notes outside of Python code)

pwd = print working directory – in my case, c:\\anaconda2

**Installation Steps:**

Download Python v2.7 and Anaconda (a free Python distribution that includes a lot of the most popular Python packages including packages for science, math, engineering and data analysis) <https://www.continuum.io/downloads>

NOTE: This is supposed to add “Anaconda Command Prompt” to the Windows start menu. It didn’t.

NOTE: I chose the 64-bit version.

Install Jupyter: In command prompt: c:\anaconda2> conda update jupyter

*Ways to run python:*

From the command prompt: c:\anaconda2> python  
 >>>

Write python programs in a text editor (Notepad, [Notepad++](https://notepad-plus-plus.org/), [Sublime Text](http://www.sublimetext.com) ($70))  
 c:\anaconda2> python program\_name.py

Write python programs in an IDE ([WingWare](https://wingware.com) ($45), [Komodo](http://komodoide.com/) ($99), [PyCharm](https://www.jetbrains.com/pycharm/), [Spyder](https://pythonhosted.org/spyder/), and [Jupyter](https://jupyter.org))

Run Jupyter locally: c:\anaconda2> jupyter notebook (do this without starting python)   
runs Jupyter on [http://localhost:8888/tree]  
anything with the .ipynb extension is a jupyter (iPython) notebook.

Access the online notebooks: <http://nbviewer.ipython.org/github/jmportilla/Complete-Python-Bootcamp/tree/master/>

NOTE: have to save each one individually (cumbersome!) to the anaconda2 directory. Displays funny once recalled.

**Other Resources:**

Stack Overflow Q&A website [www.stackoverflow.com](http://www.stackoverflow.com)

Python.org documentation <https://www.python.org/doc/>

Jupyter manual <http://jupyter.cs.brynmawr.edu/hub/dblank/public/Jupyter%20Notebook%20Users%20Manual.ipynb>

Jupyter docs <http://jupyter.readthedocs.org/en/latest/>

Print formatting - comparing old (%s) to new (.format()) <https://pyformat.info/>

Hastebin: <http://www.hastebin.com> A place to put up code for 30 days or so. Not editable.

Github: <https://github.com/vinta/awesome-python> - a curated list of awesome frameworks, libraries & software

Spyder: Scientific Python Development EnviRonment: <http://pythonhosted.org/spyder/>

Coding style guidelines: <https://www.python.org/dev/peps/pep-0008/#code-lay-out>

A more detailed answer concerning how Python code is interpreted:

<http://stackoverflow.com/questions/6889747/is-python-interpreted-or-compiled-or-both>

Git – a free and open source distributed version control system <https://www.git-scm.com>   
sets up a series of snapshots of your code (called “commits”) looking at the path of snapshots lets you see the order they were created.  
learn more about git at Git Immersion <http://gitimmersion.com>

GitHub – a webpage where you can publish your Git repositories <http://www.github.com>   
learn more about GitHub at Hello World <https://guides.github.com/activities/hello-world/>

**DIFFERENCES BETWEEN PYTHON 2 and PYTHON 3**

ISSUE

**Division**: Python 2 treats “/” as “classic division” and truncates the decimal when dividing integers   
(ie, 3/2 = 1, 2/3 = 0).   
Python 3 does “true division” (3/2 = 1.5).

**Printing**: In Python 3, print is a function, not a statement - it follows print()

**Generators and unpacking:** In Python 2, .items() builds a list of tuples that potentially eats up memory.   
In Python 3, .items() returns iterators, and a list is never built.

WORKAROUND

1. Make one of the numbers a float:  
   >>> 3/2.0
2. Cast one of the numbers as a float:  
   >>> float(3)/2
3. Use the \_ \_future\_ \_ module:  
   >>> from \_\_future\_\_ import division
4. Use the future module:  
   >>> from \_\_future\_\_ import print\_function  
   NOTE: you can’t undo this!
5. use .iteritems() instead   
   (.iteritems() is no longer used in Python 3)

From <http://stackoverflow.com/questions/9066956/why-is-python-3-not-backwards-compatible>

* print is now a function, not a statement, and using it as statement will result in an error
* various functions & methods now return an iterator or view instead of a list, which makes iterating through their results more memory-efficient (you do not need to store the whole list of results in the memory)
* cmp argument for sorting functions like sorted() and list.sort() is no longer supported, and should be replaced by key argument
* int is now the same as Python 2.x's long, which makes number processing less complex
* / operator is now an operator for true division by default (you can still use // for floor division)
* text in Python 3.x is now Unicode by default
* True, False and None are now reserved words (so you are not able to do True, False = False, True)
* changed usage of metaclass
* exceptions are required to be derived from BaseException, must be raised & caught differently than in Python 2.x

What's New in Python 3.0: <https://docs.python.org/3/whatsnew/3.0.html>

A nice PDF file: <http://ptgmedia.pearsoncmg.com/imprint_downloads/informit/promotions/python/python2python3.pdf>

**Variable names:**

1. Names can not start with a number.
2. There can be no spaces in the name, use \_ instead
3. Can’t use any of these symbols: ' " , < > / ? | \ ( ) ! @ # $ % ^ & \* ~ - +
4. It’s considered best practice (PEP8) that the names are lowercase.
5. Don't use these reserved words: and assert break class continue def del elif else except exec finally for from global if import in is lambda not or pass print raise return try while

**PYTHON PROGAMMING**

**Variable**

: reserved memory space. Can hold any value, assigned to a term. Case-sensitive. Can’t contain spaces.

**Multiple Declaration**

: var1, var2, var3 = 'apples','oranges','pears'

**Multiple Assignment**

: var1 = var2 = var3 = 'apples' (spaces/no spaces doesn’t matter)

**Data Types**

: number (integer or float), string (text), list, tuple, dictionary, set, Boolean (True, False, None)

**Operators**

: + - \* / addition, subtraction, multiplication, division  
 % modulo = gives the remainder after division  
 // floor divisor = discards the fraction without rounding  
 \*\* exponentiator

>>> 5/2 returns 2.5 NOTE: Python 2 treats '/' as 'classic division'  
>>> 5//2 returns 2 and truncates the decimal. Python 3 does   
>>> 5%2 returns 1 'true division' and always returns a float.  
>>> 5\*\*3 returns 125

Note: 2 is an *int* type number, while 2.5 is a *float*. Division returns a float. (6/3 returns 2.0)

**Relational operators:**

(aka Comparison Operators)> greater than >= greater than or equal to  
< less than <= less than or equal to  
== equal to (use == when comparing objects.   
!= not equal to One equals sign is used to assign values to objects.)  
<> not equal to

**Chained Comparison Operators:**

1 < 2 < 3 returns True (this is shorthand for 1 < 2 and 2 < 3)

**Strings**:

anything between two sets of quotation marks (single or double)  
use \n in a string to insert a line-break, \t for a tab

NOTE: strings are immutable. You can’t change elements in a string once they’re created, but you can add to them

**Lists**:

list1 = ['apples',**'oranges'**,'pears'] created using square brackets

**Tuples**:

tuple1 = (1,**2**,3) created using parentheses

*Tuple elements cannot be modified once assigned (tuples are immutable)*

max(tuple1) returns 3, min(tuple1) returns 1

Strings, lists and tuples are *sequences*. Their contents are indexed (0,1,2…)

list1[1] returns **'oranges'**

tuple1[1] returns **2**

**Dictionaries**:

contain a key and a value, using { } and colons

dict1 = {'Tom':4, 'Dick':7, 'Harry':23} created using curly braces  
dict1['Harry'] returns 23

Dictionaries are mappings, not sequences. dict1[1] would return an error.

**Sets:**

behavelike dictionaries, but only contain unique keys. Sets are unordered (not sequenced).  
set1 = set([1,1,2,2,3]) this is called "casting a list as a set"  
set1 returns {1,2,3}

**Comments:**

# (hash) provides quick one-liners  
""" (triple quotes) allow multiline full text (called docstrings) """

**WORKING WITH STRINGS**

Slices: var1[10] returns the 11th character in the string (all indexing in Python starts at 0)  
 var1[2:] returns everything after the second character (ie, it chops off the first two elements)  
 var1[:3] returns everything up to the third character (ie, the first three elements)  
 var1[1:-1] returns everything between the first and last character

Steps: var1[::2] returns every other character starting with the first (0,2,4,6…)  
 var1[::-1] returns the string *backwards* [aka Reversing a String]

Concatenate: var1 = var1 + ‘ more text’

Multiply: var1\*10 returns the var1 string 10 times

Reverse: var1[::-1] (there is no built-in reverse function or method)

Shift: var1[2:]+var1[:2] moves the first two characters to the end

**Built-in String Functions:**

len(string) returns the length of the string (including spaces)

str(object) converts objects (int, float, etc.) into strings

**Built-in String Methods:**

.upper s.upper() returns a copy of the string converted to uppercase.

.lower s.lower() returns a copy of the string converted to lowercase.

.count s.count("string") adds up the number of times a character or sequence of characters appears in a string  
 *(case-sensitive!)* NOTE: If s='hahahah' then s.count('hah') returns only 2.

.isupper s.isupper() returns true if all cased characters in the string are uppercase.   
 There must be at least one cased character. It returns false otherwise.

.islower s.islower() returns true if all cased characters in the string are lowercase.   
 There must be at least one cased character. It returns false otherwise.

.find s.find(value,start,end) finds the index position of the first occurrence of a character/phrase in a range

.replace s.replace("old","new")

*In Jupyter, hit Tab to see a list of available methods for that object.   
Hit Shift+Tab for more information on the selected method - equivalent to help(s.method)*

**Splitting Strings:**

>>> greeting = 'Hello, how are you?'

>>> greeting.split() returns ['Hello,', 'how', 'are', 'you?']

Note that the default delimiter is a space

>>> fruit = 'Apple'

>>> fruit.split('p') returns ['a', '', 'le'] (note the additional null value)

>>> fruit.partition('p') returns ('a','p','ple') (head, sep, tail)

Note also that methods work on objects, so 'The quick brown fox'.split() is valid

**Joining Strings:**

delimeter.join(list) joints a list of strings together, connected by a start string (delimeter)

>>> list1 = ['Ready', 'aim', 'fire!']

>>> ', '.join(list1) returns 'Ready, aim, fire!'

**Turning Objects Into Strings**

: str() *aka "casting objects as strings"*

>>> test = 3

>>> print('You have just completed test ' + str(test) + '.')

You have just completed test 3.

**Escape characters:**

string = 'It's a nice day' returns an error  
string = 'It\'s a nice day' handles the embedded apostrophe

\ can also break code up into multiline statements for clarity

Note: embedded apostrophes are also handled by changing the apostrophe type  
string = "It's a nice day" is also valid.

**Placeholders:**

(%s, %f et al)  *Note: the .format() method is usually preferable. See below.*

Placeholders: %s acts as a placeholder for a string, %d for a number

>>> print('Place my variable here: %s' %(string\_name))  
Note that %s converts whatever it's given into a string.

print('Floating point number: %1.2f' %(13.145))

Floating point number: 13.14   
where in 1.2, **1** is the minimum number of digits to return,   
and **2** is the number of digits to return past the decimal point.

print('Floating point number: %11.4f' %(13.145))

Floating point number: 13.1450  
There are 4 extra spaces (11 total characters incl decimal)

NOTE: %s replicates the str() function, %r replicates the repr() function to do the same thing.

Passing multiple objects:

print('First: %s, Second: %s, Third: %s' %('hi','two',3))

First: hi, Second: two, Third: 3  
Variables are passed in the order they appear in the tuple. Not very pythonic because to pass the same variable twice means repeating it in the tuple. **Use .format instead** (see below!)

Omitting the argument at the end causes the placeholder to print explicitly:

print('To round 15.45 to 15.5 use %1.1f')

To round 15.45 to 15.5 use %1.1f

…as does using %% (python sees this as a literal %)

print('To round 15.45 to %1.1f use %%1.1f') %(15.45)

To round 15.45 to 15.5 use %1.1f

**NOTE: Python 2.7 has a known issue when rounding float 5's (up/down seem arbitrary).**

See <http://stackoverflow.com/questions/24852052/how-to-deal-with-the-ending-5-in-a-decimal-fraction-when-round-it>

For better performance, use the decimal module.

**FORMAT**

Double curly-brackets serve as positional placeholders and eliminate need for str()

print('I prefer Python version {} to {}.'.format(**3.4**, 2.7)) Note the lack of quotes

I prefer Python version 3.4 to 2.7.

You can change the order of variables inside the function:

print('I prefer Python version {1} to {0}.'.format(3.4, 2.7))

I prefer Python version 2.7 to 3.4.

You can assign local variable names to placeholders:

print('First: {x}, Second: {y}, Third: {z}.'.format(x=1., z='B', y=5))

First: 1.0, Second: 5, Third: B.

Note that variables x, y and z are not defined outside of the function, and format handles the different object types.

Unlike %s placeholders, format variables may be used more than once in a string, and stored in any order.

Within the brackets you can assign field lengths, left/right alignments, rounding parameters and more

print('{0:8} | {1:9}'.format('Fruit', 'Quantity'))

print('{0:8} | {1:9}'.format('Apples', 3.))

print('{0:8} | {1:9}'.format('Oranges', 10))

Fruit | Quantity the **0** parameter takes the first object encountered

Apples | 3.0 the **8** parameter sets the minimum field length to 8 characters

Oranges | 10

By default, .format aligns text to the left, numbers to the right

print('{0:8} | {1:<8}'.format('Fruit', 'Quantity'))

print('{0:8} | {1:<8.2f}'.format('Apples', 3.66667))

print('{0:8} | {1:<8.2f}'.format('Oranges', 10))

Fruit | Quantity **<** sets a left-align (^ for center, > for right)

Apples | 3.67 **.2f** converts the variable to a float with 2 decimal places

Oranges | 10.00

You can assign field lengths as arguments:

print('{:<{}} goal'.format('field', 9))

field goal

With manual field specification this becomes {0:<{1}s}

You can choose the padding character:

print('{:-<9} goal'.format('field'))

field---- goal

You can truncate (the opposite of padding): …and by argument:

print('{:.5}'.format('xylophone')) print('{:.{}}'.format('xylophone',7))

xylop xylopho

Conversion tags enable output in either str, repr, or (in python3) ascii: { !s} { !r} { !a}

Format supports named placeholders (\*\*kwargs), signed numbers, Getitem/Getattr, Datetime and custom objects.

For more info: <https://pyformat.info>

**WORKING WITH LISTS**:

**Built-in List Functions:**

del list1[1] removes the second item from the list

len(list1) returns the number of objects in the list

len(list1[-2]) returns the number of *characters* in the second-to-last string in the list, including spaces)

**Built-in List Methods:**

.append L.append(object) -- append object to end

.count L.count(value) -> integer -- return number of occurrences of value

.extend L.extend(iterable) -- extend list by appending elements from the iterable

.index L.index(value, [start, [stop]]) -> integer -- return first index of value.

Raises ValueError if the value is not present.

.insert L.insert(index, object) -- insert object before index

.pop L.pop([index]) -> item – remove and return item at index (default last).

.remove L.remove(value) -- remove first occurrence of a value.

Raises ValueError if the value is not present.

.reverse L.reverse() -- reverse \*IN PLACE\*

.sort L.sort(cmp=None, key=None, reverse=False) -- stable sort \*IN PLACE\*;

cmp(x, y) -> -1, 0, 1

*In Jupyter, hit Tab to see a list of available methods for that object.   
Hit Shift+Tab for more information on the selected method - equivalent to help(l.method)*

Adding objects to a list: list1.append('rhubarb')

Adding multiple objects to a list: list1.extend('turnips','squash')

Adding contents of one list to another: list1.extend(list2) adds the *contents* of list2 to list1

NOTE: to add a list to another list *as one object*, use append.

list1 = ['a', 'b'] list1.extend['c', 'd'] returns ['a', 'b', 'c', 'd']  
 list1.append['c', 'd'] returns ['a', 'b', ['c', 'd']]

Inserting items into a list: list1.insert(3,'beets') puts ‘beets’ in the fourth position

Sorting items in a list: list1.sort() rewrites the list in alphabetical order IN PLACE  
 list2 = sorted(list1) creates a new list while retaining the original

Reverse sorting a list: list1.sort(reverse=True)

Reverse items in a list: list1.reverse() reverses the order of items in a list IN PLACE

Remove items from a list: list1.pop() returns the last (-1) item and permanently removes it  
 list1.pop(1) returns the second item and removes it

You can capture the popped object:  
list3 = [1,2,3,4]  
x = list1.pop()  
print(x) returns 4  
print(list3) returns [1,2,3]

To check the existence of a value in a list: object in list returns True/False as appropriate (names work too)

To join items use the *string method*: ' potato'.join(['one',', two','.'])  
 returns 'one potato, two potato.'

**List Index Method**

list.index(object) returns the index position of the *first* occurrence of an object in a list.

list1 = ['a','p','p','l','e']

list1.index('p') returns 1

**Making a list of lists:**

list1=[1,2,3] list2=[4,5,6] list3=[7,8,9]  
matrix = [list1,list2,list3]  
matrix  
[[1, 2, 3], [4, 5, 6], [7, 8, 9]]  
Note: “matrix” absorbs the *content* of the lists, not the variable names. If you later change one of the lists,   
matrix will not be affected.

Slicing:  
matrix[0] returns [1,2,3]  
matrix[0][0] returns 1 (the first object inside the first object)

Reversing:

matrix[1].reverse() returns [[1, 2, 3], [6, 5, 4], [7, 8, 9]]

Slicing with a list comprehension:  
first\_col = [row[0] for row in matrix]  
first\_col returns [1,4,7]

**LIST COMPREHENSIONS**

[**expression** for **item** in **iterable** (if **condition**)] – always return a list

allow you to perform for loops within one set of brackets

Longhand: As a comprehension:

l = [] l = [letter for letter in 'word']

for letter in 'word': print(l)

l.append(letter) ['w', 'o', 'r', 'd']

print(l)

['w', 'o', 'r', 'd']

list\_of\_squares = [x\*\*2 for x in range(6)]

result: [0, 1, 4, 9, 16, 25]

even\_numbers = [num for num in range(7) if num%2==0]

result: [0, 2, 4, 6]

Convert Celsius to Fahrenheit:

celsius = [0,10,20.1,34.5]

fahrenheit = [(temp\*(9/5)+32) for temp in celsius] type 9/5.0 in Python 2!

result: [32.0, 50.0, 68.18, 94.1]

Nested list comprehensions:

fourth\_power = [x\*\*2 for x in [x\*\*2 for x in range(6)]]

result: [0, 1, 16, 81, 256, 625]

**WORKING WITH TUPLES:**

Remember: Tuple elements cannot be modified once assigned (tuples are immutable)

tuple1 = (1,2,3)

max(tuple1) returns 3, min(tuple1) returns 1

Note: commas define tuples, not parentheses. hank = 1,2 assigns the tuple (1,2) to hank

**Built-in Tuple Methods**: (there are only 2)

.count T.count(value) -> integer -- return number of occurrences of value

.index T.index(value, [start, [stop]]) -> integer -- return first index of value.

Raises ValueError if the value is not present.

**WORKING WITH DICTIONARIES:**

dict1 = {'Tom':4, 'Dick':7, 'Harry':23}

To update a value: dict1['Harry'] = 25

To increase a value: dict1['Harry'] += 100 (the pythonic way to add/subtract/etc. value)

To clear a dictionary: dict1.clear() (keeps the dictionary, but now it’s empty of values)

To delete a dictionary: del dict1

dict1.keys() returns ['Dick', 'Tom', 'Harry']

dict1.values() returns [7,4,23] NOTE: Dictionaries are unordered objects!

dict1.items() returns [('Dick',7),('Tom',4),('Harry',23)] a list of tuples!

To add one dictionary to another: dict1.update(dict2)

Nesting dictionaries: dict3 = {'topkey':{'nestkey':{'subkey':'fred'}}}

dict3['topkey']['nestkey']['subkey'].upper() returns 'FRED'

**Dictionary Comprehensions:**

{key:value for key,value in iterable} used to create a dictionary

{key:value for value,key in iterable} used if x,y appear in y,x order in iterable

**WORKING WITH SETS**:

To declare an empty set: set1=set() (because set1={} creates an empty dictionary)

A list can be cast as a set to remove duplicates

set([2,1,2,1,3,3,4]) returns {1,2,3,4} (items are put in order, though sets do not support indexing)

A string can be cast as a set to isolate every character (case matters!)

set('Monday 3:00am') returns {' ', '0', '3', ':', 'M', 'a', 'd', 'm', 'n', 'o', 'y'}

A dictionary may use sets to store values (example of mixed drinks and their ingredients)

**Set Operators:**

**a = {1,2,3} b = {3,4,5} c = {2,3}**

1 in a returns True (set a contains a 1)

Intersection & .intersection() a&b returns {3}

Union | .union() a|b returns {1,2,3,4,5}

Difference - .difference() a-b returns {1,2} items in a but not in b

Exclusive ^ .symmetric\_difference() a^b returns {1,2,4,5} items unique to each set

Subset <= .issubset() c<=a returns True

Proper subset < c<a also returns True c has fewer items than a

Superset >= .issuperset() a>=a returns True

Proper superset < a>a returns False

**Built-in Set Methods:**

S.add(x), S.remove(x), S.discard(x), S.pop(), S.clear()  
(Not for frozen sets): adds an item, removes an item by value, removes an item if present, removes and returns an arbitrary item, removes all items. Note: .remove throws a KeyError if the value is not found. .discard doesn't.

**RANGE**

is a *generator* in Python – it returns values stepwise (see the section on 'Generators')

range([start,] stop [,step])

range(10) outputs values from 0 *up to but not including* 10

[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

range(1,10,2) NOTE: In Python 2, range() creates list objects like those shown.

[1, 3, 5, 7, 9] Use xrange() to invoke the generator (and save memory space) in for loops.

To create an actual list from a range:

list(range(6))

[0, 1, 2, 3, 4, 5]

**CONDITIONAL STATEMENTS & LOOPS**

**If / Elif / Else statements:**

>>> day = 'Tuesday' this step is called *initializing a variable*

>>> if day == 'Monday':

print('Sunny')

elif day == 'Tuesday': this step runs only when the above step returns 'false'

print('Cloudy')

else: this step runs if ALL above steps return 'false'

print('Rainy')

Cloudy you can also nest and & or in the statement

**For Loops**

(iterates through an entire set of data)

>>> for i in range(0,3): here i is a name left up to the coder that can be used elsewhere in the code

print(i)

returns: 0 1 2 Note that range(a,b) iterates from (a) to (b-1)

>>> for i in range(2,7,2):

print(i)

returns: 2 4 6

>>> l = [1,2,3,4,5]

>>> list\_sum = 0

>>> for num in l:

list\_sum += num

>>> print(list\_sum) note this "print" is outside the for loop

15 This is a clunky way to add items in a list!

**While Loops**

>>> counter = 7

>>> while counter < 10: *BEWARE OF INFINITE LOOPS!*

print(counter)

counter = counter + 1 alternatively, counter += 1

returns: 7 8 9

Note: while True: is a way to run a loop forever until some criteria is satisfied.

**Nested For Loops**

Prime number generator:

>>> for i in range (2,30):

j = 2 j is assigned as a “divisor variable”

counter = 0

while j < i:

if i % j == 0:

counter = 1

j = j + 1

else:

j = j + 1

if counter == 0:

print(str(i) + ' is a prime number')

else: - the “str” function converts integer i to a string

counter = 0

**Loop Control Statements (Break, Continue & Pass)**

counter = 0

while counter < 100:

if counter == 4:

break

print(counter)

counter = counter + 1 returns 0 to 3 instead of 0 to 99

for i in 'Python':

if i == 'h':

continue

print(i), returns P y t o n (printed downward)

Pass is used to circumvent something you haven’t written yet (like an unfinished “else”)

**Try and Except**

You can circumnavigate entire batches of code without crashing/invoking Python’s error engine

try:

code…

except Exception: if a particular exception occurs, do this

print('Uh oh!')

except: if any exception occurs, do this

print('Uh oh!')

else: if no exception occurs, then do this

finally: this code runs regardless of exceptions

To capture & log the exception:

import logging

try:

1/0

except Exception as e:

logging.exception("My error message for log")

For more info: <https://docs.python.org/2/library/logging.html>

Create your own Exception class:

class **MyException**(Exception):

pass

...and then, in the code:

if thing meets criteria:

raise **MyException**(thing)

For info on particular exceptions: <https://docs.python.org/3.4/library/exceptions.html>

**INPUT (formerly raw\_input)**

Asks for input from the user and converts whatever is typed into a string:

x = input('What would you like to input? ') Python2: use raw\_input()

What would you like to input?

If the user inputs the number 4, then x == '4'.

Use try/except and type() to handle exceptions.

**UNPACKING**

**Tuple Unpacking**

Straightforward printing of tuples in a list of tuples:

>>> l = [(2,4),(6,8),(10,12)]

>>> for tup in l:

print(tup)

(2, 4)

(6, 8)

(10, 12)

Pulling apart tuples (technique used when working with coordinate inputs)

>>> coor = (3,8)  
>>> x,y = coor  
>>> x type(x), type(y) return "int", type(coor) returns "tuple"

3  
>>> y

8

>>> y,x technically, tuples are defined by commas, not by parentheses

(8, 3)

Unpacking the first item inside tuples in a list: Perform arithmetic on items inside tuples:

>>> for (t1,t2) in l: >>> for (t1,t2) in l:

print(t1) print(t1+t2)

2 6

6 14

10 22

**Dictionary Unpacking**

.items() creates a generator to separate keys & values NOTE: use .iteritems() in Python 2!

>>> d = {'k1':1,'k2':2,'k3':3} >>> d = {'k1':1,'k2':2,'k3':3}

>>> for (k,v) in d.items(): >>> for k,v in d.iteritems():

print(k) print(k)

print(v) print(v)

k3

3

k2

2

k1

1

Remember, for k in d.items() returns a list of (key,value) tuples. use (k,v) to treat them separately.

**FUNCTIONS**

DRY - “Don’t Repeat Yourself”

def name (parameter): body

def funcName(myname): NOTE: the variable 'myname' is only used within the

print ('Hello, %s' %myname) function – we have not initialized it as a global variable

funcName('Michael') (it can’t be called elsewhere)

Hello, Michael

def funcName(fname, lname):

""" It's good practice to include a docstring

This function returns a simple greeting.

"""

print ('Hello, %s %s' %(fname, lname))

funcName('John', 'Smith')

Hello, John Smith

def Amtwtax(cost): NOTE: In Python, you don’t need to declare variable types.

return cost \* 1.0625 With "x + y", numbers are added, strings are concatenated.

print(Amtwtax(7))

7.4375

**Default Parameter Values**

You can set a default value that is overridden if when another argument is presented to the function

def funcName(fname='John', lname='Smith'):

print ('Hello, %s %s' %(fname, lname))

Will print whatever is passed to the function, otherwise prints "Hello, John Smith"

NOTE: Never use mutable objects as default parameter values! (don't use a list, dictionary, set, etc.)

**Positional Arguments \*args and \*\*kwargs**

Use \*args to pass an open number of arguments to a function:

def func1(\*args):

print(sum(args)) \*args builds a tuple of arguments named 'args'

func1(2,3,4,5)

14

Use \*\*kwargs to pass *keyworded* arguments to a function:

def func2(\*\*kwargs):

for key, value in kwargs.items(): *dictionary unpacking!*

print("%s == %s" %(key,value))

func2(happy='smile',sad='frown')

sad == frown

happy == smile \*\*kwargs builds a dictionary, which is unordered!

Note: only the asterisks \* and \*\* are needed. "args" and "kwargs" are just conventions

For more info: <http://pythontips.com/2013/08/04/args-and-kwargs-in-python-explained/>

**Inner Functions:**

Functions are objects which can be called by other functions.

**Closures:**

need to learn more about closures, and how inner functions may persist after closing…

see <http://simeonfranklin.com/blog/2012/jul/1/python-decorators-in-12-steps/> and L ubanevic's test

**PRE-DEFINED FUNCTIONS**

For a list of pre-defined functions, see <https://docs.python.org/3.4/library/functions.html>

*DON'T USE EXISTING NAMES WHEN CREATING FUNCTIONS!*

len() returns the number of items in an iterable (list, tuple, etc) or the number of characters in a string

bool() returns “True” if populated, “False” if zero or empty

abs() returns absolute value

pow() is an exponentiator. pow(2,4) returns 16.

hex() and bin() convert numbers to hexadecimal and binary, respectively.  
 hex(43) returns '0x2b', bin(43) returns '0b101011'

round() rounds to a specified number of digits (default=0). Always returns a float. 5 always rounds up.

dir() – returns every applicable function for that object  
>>> dir([]) returns all functions that can be used with lists & arrays

help() – returns help on the application of a specific function against a specific object  
>>> help(list1.count) tells you that *count* returns the number of occurrences of value   
(where *list1* is a variable previously set up in our program)

NOTE: several pre-defined functions exploit *lambda expressions*, described below.

**LAMBDA EXPRESSIONS**

– used for writing ad hoc functions, without the overhead of def

* lambda's body is a single one-line expression (not a block of statements)
* lambda is for coding simple functions (def handles the larger tasks)

Converting def to lambda:

DEF LAMBDA

def square(num): lambda num: num\*\*2

return num\*\*2

square(num)

With def, you have to assign a name to the function, and call it explicitly.

Lambda expressions can be assigned a name (eg. square = lambda num: num\*\*2), but usually they're just embedded.

Lambdas work well inside of 3 main functions: map(), filter() and reduce()

Example: a lambda expression to check if a number is even

num = 9

lambda num: num%2==0 Note: lambdas need to *return* something (here it returns False)

For further reading: Iterating with Python Lambdas <http://caisbalderas.com/blog/iterating-with-python-lambdas/>

Describes use of the map() function with lambdas.

For further reading: Python Conquers the Universe <https://pythonconquerstheuniverse.wordpress.com/2011/08/29/lambda_tutorial/>

Does a nice job of explaining how expressions (that return something) differ from assignment statements (that don't)

Lambdas can include functions [including print() ], list comprehensions, conditional expressions:

lambda x: 'big' if x > 100 else 'small'

**MORE USEFUL FUNCTIONS**

**MAP**

map(function, sequence) applies a function to all elements of the sequence, and returns a new sequence   
with the elements changed by function. NOTE: In Python 3, use list(map(… to see the output!

temp = [0, 22.5, 40, 100]

def fahrenheit(T):

return (9.0/5)\*T + 32) 9.0 insures a float return (not needed in python v3)

map(fahrenheit, temp) don't put parentheses after "fahrenheit" – you're calling

[32.0, 72.5, 104.0, 212.0] the fahrenheit *function* object, not its output

map(lambda T: (9.0/5)\*T+32, temp) use lambda in place of declared functions

[32.0, 72.5, 104.0, 212.0]

a,b,c = [1,2,3],[4,5,6],[7,8,9]

map(lambda x,y,z: x+y+z, a,b,c) function, sequence. map() returns

[12, 15, 18] a[0]+b[0]+c[0], a[1]+b[1]+c[1], etc.

**REDUCE**

reduce(function, sequence) continually applies a function to a sequence and returns a single value.

list1 = [**47,11,42,13**] the math: (**47+11**=58),(58+**42**=100),(100+13=113)

reduce(lambda x,y: x+y, list1)

113

reduce(lambda a,b: a if (a>b) else b, list1) works like max(list1)

**FILTER**

filter(function, sequence) returns only those elements for which a function returns True.

list1 = range(10)

filter(lambda x: x%2==0, list1)

[0, 2, 4, 6, 8]

**ZIP**

zip() makes an iterator that aggregates elements from each of the iterables. It stops after the shortest input iterable is exhausted. With no arguments it returns an empty iterator. Zipping two dictionaries only pairs the keys.

x,y = [1,2,3],[4,5,6]

zip(x,y)

[(1, 4), (2, 5), (3, 6)]

**ENUMERATE**

enumerate(sequence,[start=]) returns a tuple in the form (position, item).

list1 = ['a','p','p','l','e']

for x,y in enumerate(list1):

print x,y

0 a

1 p

2 p

3 l

4 e

alternatively:

list(enumerate(list1))

[(0, 'a'), (1, 'p'), (2, 'p'), (3, 'l'), (4, 'e')]

list(enumerate(list1, start=2))

[(2, 'a'), (3, 'p'), (4, 'p'), (5, 'l'), (6, 'e')]

**ALL & ANY**

all(iterable)returns True if every element is true.

any(iterable)returns True if any element is true.

**COMPLEX**

complex()accepts either a string or a pair of numbes, returns a complex number

complex(2,3) returns (2+3j) complex('4+5j') returns (4+5j)

**PYTHON THEORY & DEFINITIONS**

Variable names are stored in a **namespace**

Variable names have a **scope** that determines their visibility to other parts of code

**LEGB Rule:**L: Local — Names assigned in any way within a function (def or lambda), and not declared global in that function.  
E: Enclosing function locals — Name in the local scope of any and all enclosing functions (def or lambda),  
 from inner to outer.  
G: Global (module) — Names assigned at the top-level of a module file, or declared global in a def within the file.  
B: Built-in (Python) — Names preassigned in the built-in names module: open,range,SyntaxError,...

x = 25

**def** printer():

x = 50

**return** x

**print** printer()

**print** x

50 x inside the function is local (50)

25 x outside the function is global, and is unchanged by the function (25)

x = 25

**def** printer():

**global** x this calls global x into the function!

x = 50

**return** x

**print** printer()

**print** x

50

50 the function changed global x to 50

Use globals() and locals() to see current global & local variables

Return variable names only with globals().keys()

**In place** – "Strings are immutable; you can't change a string in place." (string[0]='n' doesn't work)

String (not mutable in place) List (mutable in place)

a='crackerjack' b= ['joe', 'ted']

a.replace('cr','sn') b.reverse()  
'snackerjack' b

a ['ted', 'joe']

'crackerjack'

Note that in this example, a.replace('cr','sn') returned 'snackerjack' without prompting, but a is unchanged.

**Sequenced** – object elements have an established order (offset), and can be sliced

**Iterable** – object contains any series of elements that can be called one-at-a-time. Sets are iterable, but not sequenced.

del is a python **statement**, not a function or method. It's sort of the reverse of assignment (=): it detaches a name from a python object and can free up the object's memory if that name was the last reference to it.

**Stack** – using .append() to add items to the end of a list and .pop() to remove them from the same end creates a data structure known as a LIFO queue. using .pop(0) to remove items from the starting end is a FIFO queue. These types of queues are called *stacks*.

**FUNCTIONS AS OBJECTS & ASSIGNING VARIABLES**

If you define a function and then assign a variable name to that function (output is in blue):

def hello(name='Fred'):

return 'Hello '+name

hello()

'Hello Fred'

greet = hello

greet

<function \_\_main\_\_.hello>

greet()

'Hello Fred'

Note that the assignment is NOT attached to the original function. If we delete hello, greet still works!   
It seems that greet was set up as its own new function, with the hello function stored as one of its methods.

Returning functions inside of functions – consider the following:

def hello(name='Fred'):

def greet():

print('This is inside the greet() function')

def welcome():

print('This is inside the welcome() function')

if name == 'Fred':

return greet note no parentheses – return the function, not its output

else:

return welcome

x = hello()

x()

This is inside the greet() function

x

<function \_\_main\_\_.greet> x is assigned to greet because name == 'Fred'

x = hello('notFred') pass any name *except* 'Fred'

x()

This is inside the welcome() function

x

<function \_\_main\_\_.welcome> x is assigned to welcome because name != 'Fred'

When x was assigned to hello(), Python ran hello and followed it's instructions – it said "return this function's greet function to x". As soon as hello() finished, greet, welcome & name were cleared from memory!

x remains as a global variable, and (until it's reassigned) it still has a copy of the embedded greet function as its object.

x is unchanged even if we change hello and run hello() elsewhere in our program. The only way to change x is to run x=hello('notFred') , run x=hello() on a changed hello, or assign x to a new object entirely.

**FUNCTIONS AS ARGUMENTS**

def hello():

return 'Hi Fred!' we carefully said "return" here, to return a string when called

def other(func): Here other is expecting an argument before it executes

print('Other code would go here')

print(func()) print whatever the *executed* function returns

other(hello) Here the hello function was passed as an argument to other

Other code would go here

Hi Fred!

**DECORATORS:**

Decorators can be thought of as functions which modify the *functionality* of another function. They help to make your code shorter and more "Pythonic". Useful when working with web frameworks like Django and Flask with python.   
Refer to the file "Python Sample Code" for an explanation of how decorators work. Decorator syntax:

def **new\_decorator**(func): new\_decorator is looking for a function as an argument

def wrap\_func():

print('Code could be here, before executing the function')

func()

print('Code here will execute after the function')

return wrap\_func returns the decorator's *function*, not its output

@**new\_decorator** the @ symbol invokes the decorator

def func\_needs\_decorator():

print(' This function is in need of a Decorator')

func\_needs\_decorator()

Code could be here, before executing the function

This function is in need of a Decorator

Code here will execute after the function

NOTE: Above code without wrap\_func:

def new\_decorator(func):

print('Code could be here, before executing the function')

func()

print('Code here will execute after the function')

@new\_decorator

def func\_needs\_decorator():

print(' This function is in need of a Decorator')

Code could be here, before executing the function

This function is in need of a Decorator

Code here will execute after the function returns the output immediately!

Whenever a function is assigned to a variable, the function *runs*, and whatever it returns is passed to the variable.

For further reading: <http://simeonfranklin.com/blog/2012/jul/1/python-decorators-in-12-steps/>

Jose Portilla (bootcamp) recommends to those wishing to become full-stack developers (?) learning the Flask framework for developing web pages with Python. see <http://flask.pocoo.org/>

To see how decorators are used in Flask: <http://flask.pocoo.org/docs/0.10/patterns/viewdecorators/>

Alternatively, check out Django: <https://www.djangoproject.com/>

per Jose, Reddit.com and Pinterest.com were developed in Python.

**GENERATORS & ITERATORS**

In Python 2, range() returns a list object, while xrange() is a generator, used to save memory space in for loops.

Generator functions send back a value, and then can pick up again where they left off.

When a generator function is compiled they become an object that supports an iteration protocol.   
That means when they are called in your code they don't actually return a value and then exit,  
rather, the generator functions will automatically suspend and resume their execution and state   
around the last point of value generation.

The main advantage here is that of not computing an entire series of values up front; the generator functions can be suspended. This feature is known as *state suspension*.

Functions become generators by using yield in place of return.

Example: Generate a Fibonnaci sequence up to n

GENERATOR: ITERATOR:

def genfibon(n): def fibon(n):

a = 1 a = 1

b = 1 b = 1

output = []

for i in range(n): for i in range(n):

yield a output.append(a)

a,b = b,a+b a,b = b,a+b

return output

for num in genfibon(10): fibon(10)

print num

returns: 1 1 2 3 5 8 13 21 34 55 returns: [1, 1, 2, 3, 5, 8, 13, 21, 34, 55]

Notice that if we call some huge value of n (like 100000) the second function will have to keep track of   
*every single result*, when in our case we actually only care about the previous result to generate the next one!

**NEXT & ITER built-in functions:**

next() is used to walk through a generator:

def simple\_gen(): | print next(g) returns 0

for x in range(3): | print next(g) returns 1

yield x | print next(g) returns 2

g = simple\_gen() | print next(g) returns a StopIteration exception

iter() turns an iterable into a iterator:

s = 'hello'

s\_iter = iter(s)

next(s\_iter) returns 'h' then 'e' then 'l' and so on

**GENERATOR COMPREHENSIONS**

Used just like list comprehensions, except they don't retain values. Use parentheses.

my\_list = [1, 3, 5, 9, 2, 6]

filtered\_gen = (item for item in my\_list if item > 3)

filtered\_gen.next()

5

filtered\_gen.next()

9

filtered\_gen.next()

6

**WORKING WITH FILES**

>>> testFile = open('test.txt') the *testFile* object now contains the contents of our text file (and the test.txt file is now open in Python)

>>> testFile.read() returns the contents as a single string in quotes. \n appears in place of line breaks.  
NOTE: the pointer is now at the END of our text file. Repeating the read function returns nothing.

>>> testFile.tell() returns the current character position of the pointer in our file

>>> testFile.seek(0,0) repositions 0 bytes of data from our pointer to the 0 position (beginning) of the file

>>> testFile.seek(0) does the same thing.

>>> testFile.close() closes the test.txt file

**READING AND APPENDING FILES**

The open function takes 3 parameters: filename, access mode & buffer size

>>> testFile = open('test.txt','w') allows writing to the file *(does it nuke the original file??)*

>>> testFile = write('new text') REPLACES the contents of the file with the words 'new text'

>>> testFile = open('test.txt','a+') allows appending to the file (a plus is needed to read the file)

>>> testFile = write('\nnew text') ADDS the words 'new text' to the end of the existing file   
 (with a line break)

**RENAMING & COPYING FILES**

>>> testFile = open('test.txt')

>>> import os imports the operating system module which allows us to  
 rename files and close files(?)

>>> os.rename('test.txt','test2.txt') test.txt has been renamed to text2.txt

>>> testFile.close()

>>> testFile = open('test2.txt')

>>> newFile = open('test3.txt','w') creates a new file test3.txt and allows writing to the file  
 (note: 'newFile' is just an arbitrary name for our variable)

>>> newFile.write(testFile.read())

**OBJECT ORIENTED PROGRAMMING – Classes, Attributes & Methods**

Classes (object types) and methods:

* using the class keyword
* creating class attributes
* creating methods in a class
* learning about Inheritance
* learning about Special Methods for classes

**Built-in types**: int, float, str, list, tuple, dict, set, function

Instances: the number 1 is an instance of the int class (objects of a particular type)

Create a new object type:

class Sample(object): by convention, class names start with a capital letter

thing1 = value here we set a "Class Object Attribute" called "thing1"

def \_\_init\_\_(self,thing2) here we initialize new attributes, and require "thing2"

self.thing2 = thing2 here we assign the "thing2" attribute

self.thing3 = thing3 a thing3 attribute is available, but not required.

def method1(self): here we define a new public method called "method1"

return self.thing2 Note: we can't say "return thing2" because thing2 isn't an object,  
 it's an attribute attached to an object

def \_method2(self): here we define a *private* method (note the single underscore)

return self.thing3 Public methods are visible by hitting Tab. Private methods aren't.

x = Sample() here we "instantiate" the class by giving it an instance

An **attribute** is a characteristic of an object. A **method** is an operation we can perform on the object.

**Methods:** Methods are functions defined inside the body of a class. They are used to perform operations with the attributes of our objects. Methods are an essential encapsulation concept of the OOP paradigm. This is essential in dividing responsibilities in programming, especially in large applications.  
You can basically think of methods as functions acting on an Object that take the Object itself into account through its self argument.  
Methods that start with a single underscore are *private* methods; they can't be seen with the Tab key.

**Inheritance:** Inheritance is a way to form new classes using classes that have already been defined. The newly formed classes are called *derived* classes, the classes that we derive from are called *base* classes. Important benefits of inheritance are code reuse and reduction of complexity of a program. The derived classes (descendants) override or extend the functionality of base classes (ancestors).

**Special Methods (aka Magic Methods):** Classes in Python can implement certain operations with special method names. These methods are not actually called directly but by Python specific language syntax (double underscore).   
They allow us to use specific functions on objects in our class.   
For more info: <http://www.rafekettler.com/magicmethods.html>

**For Further Reading:**

[Jeff Knupp's Post](https://www.jeffknupp.com/blog/2014/06/18/improve-your-python-python-classes-and-object-oriented-programming/) [Tutorials Point](http://www.tutorialspoint.com/python/python_classes_objects.htm)

[Mozilla's Post](https://developer.mozilla.org/en-US/Learn/Python/Quickly_Learn_Object_Oriented_Programming) [Official Documentation](https://docs.python.org/2/tutorial/classes.html)

Example 1:

class Dog(object):

species = 'mammal' here we assign a Class Object Attribute (all instances share this attribute)

def \_\_init\_\_(self,breed): here we initialize an attribute "breed"

self.breed = breed this calls for the attribute "breed" anytime we create a "Dog" object

def bark(self): here we define a method ".bark"

print "Woof!"

sam = Dog(breed='Lab')

frank = Dog(breed='Huskie')

sam.breed | frank.breed Note: there aren't any parentheses after ".breed" because

'Lab' | 'Huskie' it is an attribute and doesn't take any arguments

sam.species | frank.species species is also an attribute (no parentheses) shared by all intances

'mammal' | 'mammal' program output appears in blue

sam.bark()

Woof!

Example 2:

class Circle(object):

pi = 3.14

*# Circle gets initialized with a radius (default is 1)*

def \_\_init\_\_(self, radius=1):

self.radius = radius

Note: by setting radius=1 in the \_\_init\_\_, we don't require an argument when creating a Circle. x=Circle() creates a Circle object with radius 1.

*# Area method calculates the area. Note the use of self.*

def area(self):

return self.radius \* self.radius \* Circle.pi  
Note: above, we can't return just "radius" because radius isn't an object – it's an attribute of the "self" object.

Similarly, we can't return "pi" as it's a class object attribute of "Circle".

Further: we can't do "Circle.radius" as radius is an individual attribute. However, self.pi works.

*# Method for resetting radius*

def setRadius(self, radius):

self.radius = radius

This turns the assignment statement x.radius=2 into a method x.setRadius(2)

*# Method for getting radius (Same as just calling .radius)*

def getRadius(self):

return self.radius

c = Circle() Since radius was assigned a default=1, it's not a required argument here

c.setRadius(2)

print 'Radius is: ',c.getRadius()

print 'Area is: ',c.area()

Radius is: 2 output

Area is: 12.56

Example 3 - Inheritance:

class Animal(object):

def \_\_init\_\_(self):

print "Animal created" anytime an Animal is created, print "Animal created" (note that we didn't

need to initialize any attributes)

def whoAmI(self):

print "Animal"

def eat(self):

print "Eating"

class Dog(Animal): here we absorb all of Animal's attributes and methods

def \_\_init\_\_(self): here we say "whenever a Dog is created..

Animal.\_\_init\_\_(self) …initialize whatever Animal would have initialized…

print "Dog created" …and print "Dog created"

def whoAmI(self): here we override the Animal .whoAmI method

print "Dog"

def bark(self): here we introduce a new method unique to Dog

print "Woof!"

d = Dog()

Animal created output

Dog created

d.whoAmI()

Dog

d.eat() the .eat method was inherited from Animal

Eating

d.bark()

Woof!

In this example, we have two classes: Animal and Dog. The Animal is the base class, the Dog is the derived class.

The derived class inherits the functionality of the base class (as shown by the eat() method).

The derived class modifies existing behaviour of the base class (as shown by the whoAmI() method).

Finally, the derived class extends the functionality of the base class, by defining a new bark() method.

Example 4 – Special Methods:

class Book(object):

def \_\_init\_\_(self, title, author, pages):

print "A book is created"

self.title = title

self.author = author

self.pages = pages

def \_\_str\_\_(self):

return "Title: %s, author: %s, pages: %s " \

%(self.title, self.author, self.pages)

def \_\_len\_\_(self):

return self.pages

def \_\_del\_\_(self):

print "A book is destroyed"

book = Book("Python Rocks!", "Jose Portilla", 159)

*#Special Methods*

print book "print" works now because the \_\_str\_\_ method enabled it and we told it what to return

print len(book) note that just len(book) doesn't do anything visibly

del book this deletes the book object, then prints something

A book is created

Title: Python Rocks!, author: Jose Portilla, pages: 159

159

A book is destroyed

The \_\_init\_\_(), \_\_str\_\_(), \_\_len\_\_() and the \_\_del\_\_() methods:

These special methods are defined by their use of underscores. They allow us to use Python specific functions on objects created through our class.

**MODULES**

A module is a file containing Python definitions and statements. The file name is the module name with the suffix .py

To group many .py files put them in a folder. Any folder with an \_\_init\_\_.py is considered a module by python and you can call them a package

|-HelloModule

|\_ \_\_init\_\_.py

|\_ hellomodule.py

You can go about with the import statement on your module the usual way.

For more information: <http://docs.python.org/2/tutorial/modules.html#packages>

import math (or random, string, etc.)

*In Jupyter, hit Tab after* math. *to see a list of available functions for the module.*

To access a specific function: math.sqrt(4)

Alternatively, you can import specific functions from a module:

from math import sqrt (best practice!)

Then to access a function it's just: sqrt(4)

Many modules are included in Anaconda:

At the command prompt: conda install flask (flask is a web framework for creating websites with python)

For packages not distributed with Anaconda:

pip (pypi = Python Package Index) pie-pie, not pippy.

For example: To create powerpoints in python, FIRST google "python powerpoint module". First hit tells you to  
pip install python-pptx

Resource: <https://github.com/vinta/awesome-python> - a curated list of awesome frameworks, libraries & software

**COLLECTIONS Module:**

The collections module is a built-in module that implements specialized container datatypes providing alternatives to Python’s general purpose built-in containers. We've already gone over the basics: *dict, list, set,* and *tuple*.

**Counter**

is a *dict* subclass which helps count hashable objects. Inside of it elements are stored as dictionary keys and the counts of the objects are stored as the value.

from collections import Counter

Counter() with lists:

l = [1,2,2,2,2,3,3,3,2,2,1,12,3,2,32,1,21,1,223,1]

Counter(l) note the uppercase "C"

returns: Counter({2: 7, 1: 5, 3: 4, 32: 1, 12: 1, 21: 1, 223: 1})

Counter() with strings:

Counter('aabsbsbsbhshhbbsbs') note the uppercase "C"

returns: Counter({'b': 7, 's': 6, 'h': 3, 'a': 2})

Counter(s.split()) counts words in a sentence (including punctuation!)

Counter('If you read you are well read'.split())

Counter({'read': 2, 'you': 2, 'well': 1, 'are': 1, 'If': 1})

Methods with Counter

c = Counter('abacab')

print c

Counter({'a': 3, 'b': 2, 'c': 1})

c.most\_common(2) note that methods act on objects. Counter('abacab').most\_common(2) also works.

[('a', 3), ('b', 2)] not sure how it resolves ties…

Common patterns when using the Counter() object:

sum(c.values()) # total of all counts

c.clear() # reset all counts

list(c) # list unique elements

set(c) # convert to a set

dict(c) # convert to a regular dictionary

c.items() # convert to a list of (elem, cnt) pairs

Counter(dict(list\_of\_pairs)) # convert *from* a list of (elem, cnt) pairs

c.most\_common()[:-n-1:-1] # n least common elements (using string notation)

c += Counter() # remove zero and negative counts

**defaultdict**

is a dictionary-like object which provides all methods provided by dictionary but takes a first argument (default\_factory) as default data type for the dictionary. In other words, a defaultdict will never raise a KeyError.   
Any key that does not exist gets the value returned by the default factory.   
Using defaultdict is faster than doing the same using the dict.set\_default method.

from collections import defaultdict

d = defaultdict(object)

d['key1']

<object at 0x405dfd0> reserves an object spot in memory

d.keys()

['key1']

d.values()

[<object at 0x18e9ea10>]

type(d)

collections.defaultdict

Assigning objects to defaultdict: d=defaultdict(0) doesn't work (argument must be callable)

d = defaultdict(lambda: 0) essentially, "for any argument return 0"

d['key2'] = 2 works as you'd expect

d

defaultdict(<function \_\_main\_\_.<lambda>>, {'key1': 0, 'key2': 2})

**OrderedDict**

is a dictionary subclass that remembers the order in which its contents are added.   
Any key that does not exist gets the value returned by the default factory.   
Using defaultdict is faster than doing the same using the dict.set\_default method.

from collections import OrderedDict

d = OrderedDict()

d['a'], d['b'], d['c'], d['d'] = 1,2,3,4

for k,v in d.items():

print(k,v)

a 1 b 2 c 3 d 4 the order is retained

Note: two Ordered dictionaries that contain the same elements but in different order are no longer equal to each other.

**namedtuple**

Standard tuples use numerical indexes to access their members: t=(a,b,c)|t[0] returns 'a'   
Named tuples assign names as well as a numerical index to each member of the tuple

from collections import namedtuple

Dog = namedtuple('Dog','age breed name') arguments: name, attributes sep by spaces

sam = Dog(age=2,breed='Lab',name='Sammy')

sam

Dog(age=2,breed='Lab',name='Sammy')

sam.age | sam[0]

2 | 2 note that "age" is the *name* of the first member of the tuple, "2" is its *value*

You don't need to include names when creating individual namedtuples:

dave = Dog(3,'beagle','David')

dave

Dog(age=3, breed='beagle', name='David')

In Jupyter, if you hit Tab after sam. you see all the attributes associated with Dog (as well as count & index)

Each named tuple is like an ad hoc *class*.

**DATETIME Module**

Introduces a *time* class which has attributes such as hour (req'd), minute, second, microsecond, and timezone info.

import datetime

t = datetime.time(5,25,1)

print(t) returns 05:25:01, t.minute returns 25

t.min is 00:00:00, t.max is 23:59:59.999999, t.resolution is 0:00:00.000001

The *date* class:

today = datetime.date.today()

print(today) returns 2016-01-06

today.timetuple() returns time.struct\_time(tm\_year=2016, tm\_mon=1, tm\_mday=15, tm\_hour=0, tm\_min=0, tm\_sec=0, tm\_wday=4, tm\_yday=15, tm\_isdst=-1)

print datetime.date.resolution returns 1 day, 0:00:00

d2 = d1.replace(year=1990) NOTE: d1.replace(…) returns a new value, but doesn't change d1.

Arithmetic:

d1-d2 returns the time delta in days (date.resolution) although you can control this with additional code

Question: if print datetime.date.min returns 0001-01-01 how does datetime handle dates BCE?

**TIMEIT Module**

The timeit module has both a Command-Line Interface as well as a callable one. It avoids a number of common traps for measuring execution times.

import timeit

timeit.timeit(CODE, number=10000)

returns 0.24759 (or similar) after running CODE 10,000 times

iPython's "built-in magic" %timeit function returns the best-of-three fastest times on one line of code:

%timeit "-".join(str(n) for n in range(100)) *Works in Spyder!*

10000 loops, best of 3: 23.8 µs per loop

Note that %timeit set the 10,000 loops limit. If code ran longer it would have adjusted downward to 1000 or 100.

**PYTHON DEBUGGER – the pdb Module**

The debugger module implements an interactive debugging environment for Python programs.

It allows you to pause programs, look at the values of variables, and watch program executions step-by-step.

import pdb

When you find a section of code causing an error, insert

pdb.set\_trace() above it.

The program will execute up until set\_trace, an then invoke the debugging environment:

(Pdb)

Here you can call variables to determine their values, try different operations on them, etc.

(Pdb) continue returns you to the program

(Pdb) q quits out of the program

For further reading: <https://docs.python.org/3/library/pdb.html>

**REGULAR EXPRESSIONS – the re Module**

Regular expressions are text matching patterns described with a formal syntax. You'll often hear regular expressions referred to as 'regex' or 'regexp' in conversation. Regular expressions can include a variety of rules, from finding repetition, to text-matching, and much more. As you advance in Python you'll see that a lot of your parsing problems can be solved with regular expressions (they're also a common interview question!).

If you're familiar with Perl, you'll notice that the syntax for regular expressions are very similar in Python. We will be using the **re** module with Python for this lecture. See <https://docs.python.org/3/library/re.html>

Searching for Patterns in Text

import re

*# List of patterns to search for*

patterns = ['term1', 'term2'] Use a list & for loop to conduct multiple searches at once

*# Text to parse*

text = 'This is a string with term1, but it does not have the other term.'

for pattern in patterns:

print 'Searching for "%s" in: \n"%s"' %(pattern, text)

*#Check for match*

if re.search(pattern, text):

print '\n'

print 'Match was found. \n'

else:

print '\n'

print 'No Match was found.\n'

Searching for "term1" in:

"This is a string with term1, but it does not have the other term."

Match was found.

Searching for "term2" in:

"This is a string with term1, but it does not have the other term."

No Match was found.

Note that re.search returns a *Match* object (or None). The Match object includes info about the start and end index of the pattern.

Note: re.match checks for a match only at the *beginning* of a string.

Finding all matches

Where .search found the first match, .findall returns a list of all matches.

re.findall('match','test phrase match is in middle')

['match'] Note: this is a list of ordinary text objects, *not* Match objects. Not very useful except you  
 can count the result to determine how many matches there were.

Split with regular expressions

*# Term to split on*

split\_term = '@' splits on *every occurrence* in the phrase

​phrase = "Bob's email address is: bob@gmail.com"

*​# Split the phrase*

re.split(split\_term,phrase)

["Bob's email address is: bob", 'gmail.com'] nice that it handled the single quote.

Using metacharacters

Repetition Syntax: there are five ways to express repetition in a pattern:

'sd\*' s followed by zero or more d's

'sd+' s followed by one or more d's

'sd?' s followed by zero or one d's

'sd{3}' s followed by three d's

'sd{2,3}' s followed by two to three d's

Character Sets: use brackets to match any one of a group of characters:

'[sd]' either s or d

's[sd]+' s followed by one or more s or d

NOTE: Matches don't overlap.

Exclusion: use ^ with characters in brackets to find all but those characters:

re.findall('[^!,.? ]+',phrase) will strip all ! , . ? and spaces from a phrase   
 including combinations (', ' is stripped) leaving a list of words

Character Ranges: use [start-end] to find occurrences of specific ranges of letters in the alphabet:

'[a-z]+' sequences of lower case letters

'[A-Z]+' sequences of upper case letters

'[a-zA-Z]+' sequences of lower or upper case letters

'[A-Z][a-z]+' one upper case letter followed by lower case letters

Escape Codes: use to find specific types of patterns:

\d a digit

\D a non-digit

\s whitespace (tab, space, newline, etc.)

\S non-whitespace

\w alphanumeric

\W non-alphanumeric

NOTE: both the bootcamp lecture and [TutorialsPoint](http://www.tutorialspoint.com/python/python_reg_expressions.htm) advise the use of *raw strings*, obtained by putting **r** ahead of a text string: r'expression'.

**IO MODULE**

The io module implements an in-memory file-like object. This object can then be used as input or output to most functions that would expect a standard file object.

import io

message = 'This is a normal string.'

f = io.StringIO(message) use the StringIO method to set text as a file-like object

Now we have an object f that we can treat just like a file. For example:

f.read()

'This is a normal string.'

We can also write to it:

f.write(' Second line written to file-like object')

f.seek(0) Resets the cursor just like you would a file

f.read()

'This is a normal string. Second line written to file-like object'

Use io.BytesIO(data) for data

This has various use cases, especially in web scraping where you want to read some string you scraped as a file.   
For more info: <https://docs.python.org/3.4/library/io.html>

SEE ALSO: The cStringIO module provides a faster alternative.

NOTE: Python 2 had a StringIO module. The command above would be f=StringIO.StringIO(message). f becomes an *instance* type. For details see <https://docs.python.org/2/library/stringio.html>

**STYLE AND READABILITY (PEP 8)**

See <https://www.python.org/dev/peps/pep-0008/>

Continuation lines should align wrapped elements either vertically using Python's implicit line joining inside parentheses, brackets and braces, or using a hanging indent. When using a hanging indent the following considerations should be applied; there should be no arguments on the first line and further indentation should be used to clearly distinguish itself as a continuation line.

foo = long\_function\_name(var\_one, var\_two, it's ok to have arguments on the first line

var\_three, var\_four) if aligned with opening delimeter

def long\_function\_name( do NOT put arguments on the first line

var\_one, var\_two, var\_three, when using hanging indents, and use further

var\_four): indentation to distinguish from neighboring code

print(var\_one)

The closing brace/bracket/parenthesis on multi-line constructs may either line up under the first non-whitespace character of the last line of list, as in:

my\_list = [

1, 2, 3,

4, 5, 6,

]

Limit lines to 79 characters

Surround top-level function and class definitions with two blank lines, method definitions inside a class by a single blank line.

Always surround these binary operators with a single space on either side: assignment ( = ), augmented assignment ( += , -= etc.), comparisons ( == , < , > , != , <> , <= , >= , in , not in , is , is not ), Booleans ( and , or , not ).

HOWEVER: If operators with different priorities are used, consider adding whitespace around the operators with the lowest priority(ies). Use your own judgment; however, never use more than one space, and always have the same amount of whitespace on both sides of a binary operator.

Yes: x = y + z No: x=y+z

var1 += 1 var1 +=1

x = y\*y + z\*z x = y \* y + z \* z

c = (a+b) \* (a-b) c = (a + b) \* (a - b)

Don't use spaces around the = sign when used to indicate a keyword argument or a default parameter value.

Yes: def complex(real, imag=0.0): No: def complex(real, imag = 0.0):

return magic(r=real, i=imag) return magic(r = real, i = imag)

Use string methods instead of the string module.

Use ''.startswith() and ''.endswith() instead of string slicing to check for prefixes or suffixes.

startswith() and endswith() are cleaner and less error prone. For example:

Yes: if foo.startswith('bar'):

No: if foo[:3] == 'bar':

Be consistent in return statements. Either all return statements in a function should return an expression, or none of them should. If any return statement returns an expression, any return statements where no value is returned should explicitly state this as return None , and an explicit return statement should be present at the end of the function (if reachable).

Yes: def foo(x): No: def foo(x):

if x >= 0: if x >= 0:

return math.sqrt(x) return math.sqrt(x)

else:

return None

def bar(x): def bar(x):

if x < 0: if x < 0:

return None return

return math.sqrt(x) return math.sqrt(x)

Object type comparisons should always use isinstance() instead of comparing types directly.

Yes: if isinstance(obj, int):

No: if type(obj) is type(1):

Refer to the PEP8 documentation for further info on naming & coding recommendations and conventions.

Check code at <http://pep8online.com/>

**GOING DEEPER:**

**The '\_' variable**

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:

>>>

**>>>** tax = 12.5 / 100

**>>>** price = 100.50

**>>>** price \* tax

12.5625

**>>>** price + \_

113.0625

**>>>** round(\_, 2)

113.06

This variable should be treated as read-only by the user. Don’t explicitly assign a value to it — you would create an independent local variable with the same name masking the built-in variable with its magic behavior.

**To print on the same line:**

print 'Hello' print 'Hello', Python 2: use a comma to avoid the automatic line break

print 'World' print 'World' (adds a space)

Hello Hello World

World

print('Hello', end='') Python 3: replace the default \n with an empty string

print('World') (does NOT add a space, unless you say end=' ')

HelloWorld

counter += 1 is equivalent to counter = counter + 1. This works for all operators (-=, \*=, /= etc.)

the divmod function does // and % at once, returning a 2-item tuple: divmod(9,5) returns (1,4)

tuples that contain a single item still require a comma: tuple1 = (item1,)

you can convert lists to tuples and tuples to lists using tuple() and list() respectively

strings, lists and tuples are sequences - can be indexed [0,1,2…]. dictionaries are mappings, indexed by their keys.

You can assign the Boolean values “True”, “False” or “None” to a variable.   
“None” returns nothing if the variable is called on - it’s used as a placeholder object.

you can combine *literal strings* (but not string variables) with "abc""def" (this is the same as "abc"+"def")

**Some more (& obscure) built-in string methods:**

.strip s.strip('.') removes '.' sequences from both ends of a string

.startswith s.startswith(string) returns True or False, depending

.endswith s.endswith(string) returns True or False, depending

.find s.find(value,start,end) finds the index position of the first occurrence of a character/phrase in a range

.rfind s.find(value,start,end) finds the index position of the last occurrence of a character/phrase in a range

.isalnum s.isalnum() returns True if all characters are either letters or numbers (no punctuation)

.isalpha s.isalpha() returns True if all characters are letters

.islower s.islower() returns True if all cased characters are lowercase (may include punctuation)

.isupper s.isupper() returns True as above, but uppercase

.isspace s.isspace() returns True if all characters are whitespace

.istitle() s.istitle() returns True if lowercase characters always follow uppercase, and uppercase follow uncased  
 *Note that 'McDonald'.istitle() returns False*

.capitalize s.capitalize() capitalizes the first word only

.title s.title() capitalizes all the words

.swapcase s.swapcase() changes uppercase to lower and vice versa

.center s.center(30) returns a copy of the string centered in a 30 character field bounded by whitespace

s.center(30,'z') does as above, but bounded by 'z's

.ljust s.ljust(30) as above, but left-justified

.rjust s.rjust(30) as above, but right-justified

.replace s.replace('old', 'new', 10) replaces the first 10 occurrences of 'old' with 'new' (see *regular expressions*)

.expandtabs 'hello\thi'.expandtabs() returns 'hello hi' without requiring the print() function

**Some more (& obscure) built-in set methods:**

(capital S used to distinguish these from string methods)

S.copy() returns a copy of S

S1.difference(S2) returns a set of all items in S1 that are not in S2 (but not the other way around).  
 If S1<=S2, S1.difference(S2) returns an empty set.

S1.difference\_update(S2) removes any items from S1 that exist in S2

S1.intersection(S2) returns items in common between the two sets.

S1.intersection\_update(S2) removes any items from S1 that *don't* exist in S2.

S1.isdisjoint(S2) returns True if there are no items in common between the two sets

S1.issubset(S2) returns True if every item in S1 exists in S2

S1.issuperset(S2) returns True if every item in S2 exists in S1

S1.union(S2) returns all items that exist in either set

S1.symmetric\_difference(S2) returns all items in either set not common to the other

S1.update(S2) adds items from S2 not already in S1

Advantages of Python 3 over Python 2 (and other languages):  
integers can be any size (not just 64-bit as Python 2 “long”s)  
Unicode support (not just ASCII) allows text in any language

Need to figure out repr() vs ascii() handling of objects betwn v2 & v3

The ordering comparison operators (<, <=, >=, >) raise a TypeError exception when the operands don’t have a meaningful natural ordering. In Python 2, 'string'>100000 returned True because it was comparing the type names, not the items themselves, and 'str' is greater than 'int' alphabetically.

Map behaves differently in Python 3 – it returns an iterable object, not a list. To see the result, use list(map(…

**Common Errors & Exceptions:**

Error Trigger

IndexError: list index out of range tried to call the fifth item in a four-item list

ValueError tried to remove a list value that wasn't present

List methods like .sort and .reverse permanently affect the objects they act on.

list2=list1.reverse() reverses list1, but doesn't assign anything to list2 (weird!).

list1.sort(reverse=True) is NOT the same as list1.reverse() (one sorts, the other doesn't)

pow(x,y[,z]) accepts a third "mod" argument for efficiency cases. pow(2,4) = 16, pow(2,4,3)=1

LaTeX – the .Latex method provides a way for writing out mathematical equations (need to learn more!)

Python Debugger resources:

Read Steve Ferb's article ["Debugging in Python"](http://pythonconquerstheuniverse.wordpress.com/2009/09/10/debugging-in-python/)

Watch Eric Holscher's screencast ["Using pdb, the Python Debugger"](http://ericholscher.com/blog/2008/aug/30/using-pdb-python-debugger-django-debugging-series-/)

Read Ayman Hourieh's article ["Python Debugging Techniques"](https://gimmebar-assets.s3.amazonaws.com/4fe38b76be0a5.html)

Read the [Python documentation for pdb — The Python Debugger](http://docs.python.org/library/pdb.html)

Read Chapter 9—When You Don't Even Know What to Log: Using Debuggers—of Karen Tracey's [Django 1.1 Testing and Debugging](https://www.packtpub.com/django-1-1-testing-and-debugging/book).

**For more practice:**

Basic Practice:

<http://codingbat.com/python>

More Mathematical (and Harder) Practice:

<https://projecteuler.net/archives>

List of Practice Problems:

<http://www.codeabbey.com/index/task_list>

A SubReddit Devoted to Daily Practice Problems:

<https://www.reddit.com/r/dailyprogrammer>

A very tricky website with very few hints and tough problems (Not for beginners but still interesting)

<http://www.pythonchallenge.com/>

**Rounding issues in Python**

Python has a known issue when rounding float 5's (up/down seem arbitrary).

See <http://stackoverflow.com/questions/24852052/how-to-deal-with-the-ending-5-in-a-decimal-fraction-when-round-it>

PYTHON 2.7 & 3.5 gave the same output:

a = [1.25,1.35,1.45,1.55,1.65,1.75,1.85,1.95,2.05]

for i in a:

print '%1.1f'%(i)

1.2

1.4

1.4

1.6

1.6

1.8

1.9

1.9

2.0

For better performance, use the decimal module.

**Adding a username & password**

From the Udemy course "Rock, Paper, Scissors – Python Tutorial" by Christopher Young

while True:

username = input("Please enter your username: ")

password = input("Please enter your password: ")

searchfile = open("accounts.csv", "r")

for line in searchfile:

if username and password in line:

print("Access Granted")

**Picking a random rock/paper/scissors**

import random

plays = ('rock', 'paper', 'scissors')

choice1 = random.choice(plays)

**Referential Arrays**

counters = [0]\*8 creates a list of 8 references to the same 0 integer value

counters = [2] += 1 creates a new integer value 1, and cell 2 now points to it

counters.extend(extras) adds pointers to the same list items that extras points to

**Deep and shallow copies**

new\_list = first\_list the new list points to the first list.   
 Changes made to either one affect the other

new\_list = copy(first\_list) creates a "shallow copy" – the new list points to the   
 same objects as the first one, but independently of the first

import copy

new\_list = copy.deepcopy(first\_list) creates a deep copy – it makes copies of the objects themselves   
 so long as those elements were mutable

**Dynamic Arrays**

In Python you do not have to set a list length ahead of time.

A list instance often has greater capacity than current length

If elements keep getting appended, eventually this extra space runs out.

import sys includes a "get size of" function that tells how many bytes python is holding in memory

n = 10

data = []

for i in range(n):

a = len(data)

b = sys.getsizeof(data)

print('Length: {0:3d}, Size in bytes: {1:4d}'.format(a,b))

data.append(n)

Length: 0, Size in bytes: 64

Length: 1, Size in bytes: 96 python sets aside a larger number of bytes

Length: 2, Size in bytes: 96 than what it needs as items are being added

Length: 3, Size in bytes: 96

Length: 4, Size in bytes: 96

Length: 5, Size in bytes: 128

Length: 6, Size in bytes: 128

Length: 7, Size in bytes: 128

Length: 8, Size in bytes: 128

Length: 9, Size in bytes: 192

**More ways to break out of loops (in "Goto" fashion)**

From <https://docs.python.org/2/faq/design.html#why-is-there-no-goto>

You can use exceptions to provide a “structured goto” that even works across function calls. Many feel that exceptions can conveniently emulate all reasonable uses of the “go” or “goto” constructs of C, Fortran, and other languages.

For example:

class label: pass # declare a label

try:

...

if condition: raise label() # goto label

...

except label: # where to goto

pass

...

**Bitwise Operators:**

Code: Meaning: Result:

print 5 >> 4 # Right Shift 0

print 5 << 1 # Left Shift 10

print 8 & 5 # Bitwise AND 0

print 9 | 4 # Bitwise OR 13

print 12 ^ 42 # Bitwise XOR 38

print ~88 # Bitwise NOT -89

**The Exclusive Or (bitwise XOR) operator:**

the ^ carat symbol

**PYTHON "GOTCHA": Default Arguments**  
from <https://developmentality.wordpress.com/2010/08/23/python-gotcha-default-arguments/>)

Python permits default arguments to be passed to functions:

def defaulted(a, b='b', c='c'):

print a,b,c

defaulted(1,2,3)

1 2 3

defaulted(1)

1 b c

Unfortunately, mutable default objects are shared between subsequent calls (they're only predefined once):

def f(a, L=[]):

L.append(a)

return L

print f(1) Returns: [1]

print f(2) [1, 2]

print f(3) [1, 2, 3]

There are two solutions:

def f(a, L=None): def f(a, L=[]):

if L is None: L = L + [a]

L = [] return L

L.append(a)

return L