Web Server Design

Lecture 2 – Introduction to Python

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What is Python?

- A free and open source programming language
- Scripting language
- Interpreted and Compiled
- Cross-platform
- Dynamically typed
- Object-oriented (but not enforced)
- White-spaces for block indentation
- Integrates with other languages
- Developed in 1980s

Why Python?

- Fast development and prototyping
- Easy to test
- Rich standard library
- Rich community contributed libraries and modules
- Less boilerplate code
- Easy to read and write

Expression vs. Statement

Expression

- Represents something
- Python **Evaluates** it
- Results in a value
- Example:
  - "Hello" + " " + "World!"
  - (5*3)-1.4

Statement

- Does something
- Python **Executes** it
- Results in an action
- Example:
  - print("Hello World!")
  - import os

Differences with C/C++ Syntax

- White spaces for indentation
- No "{}" for blocks
- Blocks begin with ":" (in the preceding line)
- NO type declarations needed
- No ++, -- operators
- Several differences in keywords
- No && and || ("and" and "or" instead)
- No switch/case

Interactive Python Shell

```
$ python
Python 3.7.4 (default, Sep 12 2019, 15:40:15)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> help(print)
Help on built-in function print in module builtins:

print(...)
    print(value, ..., sep=' ', end='\n', file=sys.stdout, flush=False)

    Prints the values to a stream, or to sys.stdout by default.
    Optional keyword arguments:
    file:  a file-like object (stream); defaults to the current sys.stdout.
    sep:   string inserted between values, default a space.
    end:   string appended after the last value, default a newline.
    flush: whether to forcibly flush the stream.

>>> print("Hello World!")
Hello World!
>>> 2 + 3 * 4 / 5
4.4
>>> exit
Use exit() or Ctrl-D (i.e. EOF) to exit
>>> exit()
$
```

Simple Data Types

- **Integer:** 7
- **Float:** 87.23
- **String:** "abc", 'abc'
- **Bytes:** b"abc", b'abc'
- **Boolean:** False, True

Compound Data Types

- **List:** ["Hello", "There"]
- **Tuple:** ("John", "Doe", 35)
- **Set:** {"Python", "Ruby", "Perl"}
- **Dictionary:** {"name": "John Doe", "age": 35}

String

- Concatenation: "Python" + "Rocks" → "PythonRocks"
- Repetition: "Python" * 2 → "PythonPython"
- Slicing: "Python"[2:3] → "th"
- Size: len("Python") → 6
- Index: "Python"[2] → 't'
- Search: "x" in "Python" → False
- Comparison: "Python" < "ZOO" → True (lexicographically)

String vs. Bytes

- Bytes object is s sequence of bytes
- String is a sequence of characters (often in UTF-8)

```
>>> type("Hello")
<class 'str'>
>>> type(b"Hello")
<class 'bytes'>
>>> b"Hello".decode()
'Hello'
>>> "Hello".encode()
b'Hello'
```

List

- Equivalent to arrays
- X = [0, 1, 2, 3, 4]
  - Creates a pre-populated array of size 5.
- Y = [ ]
  - Creates an empty list
- X.append(5)
  - X becomes [0, 1, 2, 3, 4, 5]
- len(X)
  - Gets the length of X which is 6

List

```
>>> mylist = [0, 'a', "hello", 1, 2, ['b', 'c', 'd']]
>>> mylist [1]
a
>>> mylist [5][1]
c
>>> mylist[1:3]
['a', "hello", 1]
>>> mylist[:2]
[0, 'a', "hello"]
>>> mylist[3:]
[1, 2, ['b', 'c', 'd']]
>>> mylist.remove('a')
>>> mylist
[0, "hello", 1, 2, ['b', 'c', 'd']]
```

List

```
>>> mylist.reverse()    → Reverse elements in list
>>> mylist.append(x)    → Add element to end of list
>>> mylist.sort()       → Sort elements in list ascending
>>> mylist.index('a')   → Find first occurrence of 'a'
>>> mylist.pop()        → Removes last element in list
```

Tuple

- X = (0, 1, 2, 3, 4)
  - Creates a pre-populated list of fixed size 5
  - Immutable (can’t be changed)
- print(X[3]) #=> 3

List vs. Tuple

- Lists are mutable, tuples are immutable
- Lists can be resized, tuples can't
- Tuples can be faster than lists

Dictionary

- An array indexed by strings (equivalent to hashes)

```
>>> marks = {"science": 90, "art": 25}
>>> print(marks["art"])
25
>>> marks["chemistry"] = 75
>>> print(marks.keys())
["science", "art", "chemistry"]
```

Dictionary

- dict = { "fish": 12, "cat": 7}
- 'dog' in dict (Is 'dog' a key?)
- dict.keys() (Gets a list of all keys)
- dict.values() (Gets a list of all values)
- dict.items() (Gets a list of all key-value tuples)
- dict["fish"] = 14 (Assignment)

Variables

- Everything is an object
- No need to declare
- No need to assign
- Not strongly typed
- Assignment = reference
  - Ex:
```
>>> X = ['a', 'b', 'c']
>>> Y = X
>>> Y.append('d')
>>> print(X)
['a', 'b', 'c', 'd']
```

User Input

Without a Message:

```
>>> x = input()
3
>>> x
'3'
```

With a Message:

```
>>> x = input('Enter the number: ')
Enter the number: 3
>>> x
'3'
```

Evaluate User Input

```
>>> x = input()
3+4
>>> x
'3+4'
>>> eval(x)
7
```

File Read

```
>>> f = open("input_file.txt", "r")
```

File handle — Name of the file — Mode

```
>>> line = f.readline()
```

Read one line at a time

```
>>> f.close()
```

Stop using this file and close

File Write

```
>>> f = open("output_file.txt", "w")
```

File handle — Name of the file — Mode

```
>>> line = f.write("Hello World!")
```

Write a string to the file

```
>>> f.close()
```

Stop using this file and close

Control Flow

- Conditions:
  - if
  - if / else
  - if / elif / else
- Loops:
  - while
  - for
  - for loop on iterators

Conditions

- The condition must be terminated with a colon ":"
- Scope of the loop is the following indented section

```
>>> if score == 100:
        print("You scored a hundred!")
    elif score > 80:
        print("You are an awesome student!")
    else:
        print("Go and study!")
```

While Loop

```
>>> i = 0
>>> while i < 10:
        print(i)
        i = i + 1
```

Do not forget the : at the end of the condition!

For Loop

```
>>> for i in range(10):
        print(i)

>>> myList = ['hany', 'john', 'smith', 'aly', 'max']
>>> for name in myList:
        print(name)
```

Do not forget the : at the end of the condition!

Inside vs. Outside Block

```
for i in range(3):
    print("Iteration {}".format(i))
    print("Done!")
```

```
Iteration 0
Done!
Iteration 1
Done!
Iteration 2
Done!
```

```
for i in range(3):
    print("Iteration {}".format(i))
print("Done!")
```

```
Iteration 0
Iteration 1
Iteration 2
Done!
```

Loop Over a File Iterator

```
>>> f = open ("my_ file.txt", "r")
>>> for line in f:
        print(line)
```

Pass Empty Block

- It means do nothing

```
>>> if x > 80:
        pass
    else:
        print("You are less than 80!")
```

Break the Loop

- It means quit the loop

```
>>> for name in myList:
        if name == "aly":
            break
        else:
            print(name)
```

→This will print all names before “aly”

Continue to the Next Iteration

- It means skip this iteration of the loop

```
>>> for name in myList:
        if name == "aly":
            continue
        else:
            print(name)
```

→This will print all names except “aly”

Functions

- Finding the biggest number in a list:

```
mylist = [2,5,3,7,1,8,12,4]
maxnum = 0
for num in mylist:
   if (num>maxnum):
      maxnum = num
print("The biggest number is: {}".format(maxnum))
```

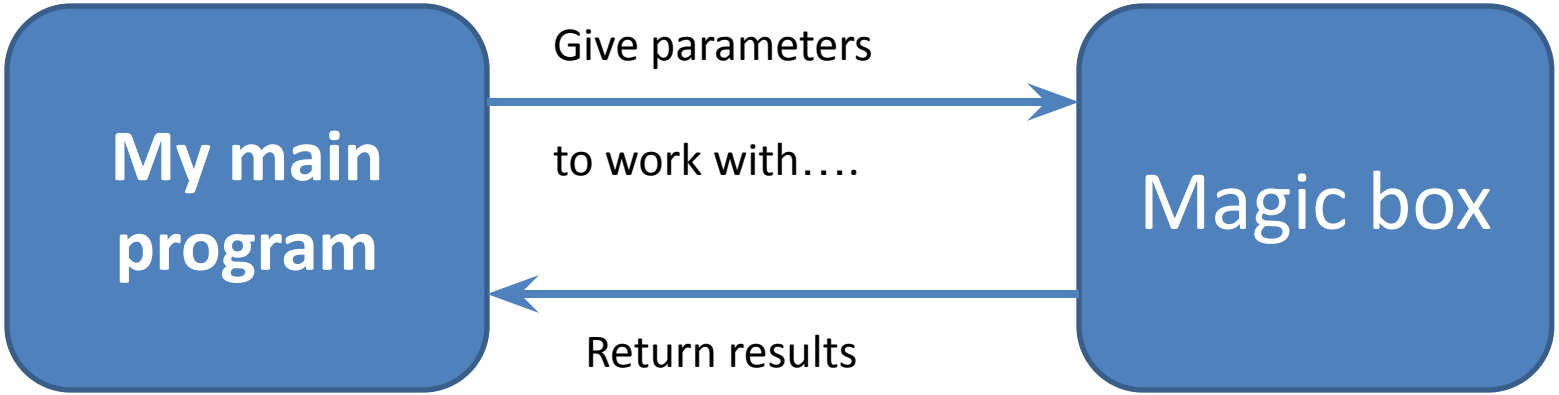
Functions

- What if the code is a bit more complicated and long?
- What if the same logic is repeated?

- Writing the code as one blob is bad!
  - Harder to read and comprehend
  - Harder to debug
  - Rigid
  - Non-reusable

Functions

```
def my_funtion(parameters):
    do stuff
```



Functions

- Back to our example:

```
mylist = [2,5,3,7,1,8,12,4]
maxnum = getMaxNumber(mylist)
print("The biggest number is: {}".format(maxnum))
```

Functions

- Implement the function getMaxNumber as you wish

```
def getMaxNumber(list_x):
    maxnum = 0
    for num in list_x:
        if (num > maxnum):
            maxnum = num
    return maxnum
```

Testing

```
def getMaxNumber(list_x):
    """
    Returns the maximum number from the supplied list
    >>> getMaxNumber([4, 7, 2, 5])
    7
    >>> getMaxNumber([-3, 9, 2])
    9
    >>> getMaxNumber([-3, -7, -1])
    -1
    """
    maxnum = 0
    for num in list_x:
        if (num>maxnum):
            maxnum = num
    return maxnum

if __name__ == '__main__':
    import doctest
    doctest.testmod()
```

```
$ python max_num.py
**********************************************************************
File "max_num.py", line 8, in __main__.getMaxNumber
Failed example:
    getMaxNumber([-3, -7, -1])
Expected:
    -1
Got:
    0
**********************************************************************
1 items had failures:
   1 of   3 in __main__.getMaxNumber
***Test Failed*** 1 failures.
```

Functions

```
def getMaxNumber(list_x):
    return max(list_x)
```

Functions

- All arguments are passed by value
- All variables are local unless specified as global
- Functions in Python can have several arguments or None
- Functions in Python can return several results or None

Functions Return Multiple Values

```
def getMaxNumberAndIndex(list_x):
    maxnum = 0
    index = -1
    i = 0
    for num in list_x :
        if (num>maxnum):
            maxnum = num
            index = i
        i = i + 1
    return maxnum, index
```

Calling Multi-values Function

```
mylist = [2,5,3,7,1,8,12,4]
maxnum, idx = getMaxNumberAndIndex(mylist)
print("The biggest number is: {}".format(maxnum))
print("It’s index is: {}".format(idx))
```

Class

```
class Student:
    count = 0                           # class variable
    def __init__(self, name):           # Initializer
        self.name = name
        self.grade = None
        Student.count += 1
    def updateGrade(self, grade):       # Instance method
        self.grade = grade
if __name__ == "__main__":              # Execute only if script
    s = Student("John Doe")
    s.updateGrade("A+")
    s.grade                             #=> "A+"
    Student.count                       #=> 1
```

Comments

```
mylist = [2,5,3,7,1,8,12,4]
# The function getMaxNumberAndIndex will be called next to retrieve
# the biggest number in list "mylist" and the index of that number
maxnum, idx = getMaxNumberAndIndex(mylist)
print("The biggest number is: {}".format(maxnum))
print "It's index is: {}".format(idx))
```

Python Files

- Python files end with ".py"
- To execute a python file you write:

```
$ python myprogram.py
```

Python Scripts

- To make the file “a script”, set the file permission to be executable and add this shebang in the beginning:

```
#!/usr/bin/python
```

or better yet

```
#!/usr/bin/env python3
```

Modules

- We just call the math library that has the perfect implementation of square root

```
>>> import math
>>> x = math.sqrt(9.0)
```

Or

```
>>> from math import sqrt
>>> x = sqrt(9.0)
```

Command-line Arguments

- To get the command line arguments:
- *>>> import sys*

- The arguments are in *sys.argv* as a *list*

Exception Handling

```
>>> sum_grades = 300
>>> number_of_students = input()
0
>>> average = sum_grades / number_of_students

→ Error! Divide by Zero
```

Remember: User input is evil!

Exception Handling

```
try:
    average = sum_grades / number_of_students
except:
    # This catches if something wrong happens
    print("Something wrong happened, please check it!")
    average = 0
```

Exception Handling

```
try:
    average = sum_grades / number_of_students
except ZeroDivisionError:
    # This catches if something wrong happens
    print("Something wrong happened, please check it!")
    average = 0
```

Exception Handling

```
try:
    number_of_students = input()
    average = sum_grades / number_of_students
except ZeroDivisionError:
    # This catches if a number was divided by zero
    print("You Evil User!.....you inserted a zero!")
    average = 0
except IOError:
    # This catches errors happening in the input process
    print("Something went wrong with how you enter words")
    average = 0
```

Generators

```
>>> def fib():
        a = b = 1
        while True:
            yield a
            a, b = b, a + b

>>> f = fib()
>>> print(next(f))  #=> 1
>>> print(next(f))  #=> 1
>>> print(next(f))  #=> 2
>>> print(next(f))  #=> 3
>>> print(next(f))  #=> 5
```

Regular Expression

- A powerful tool to deal with patterns in String and Bytes

```
>>> import re
>>> status = "HEAD /foo HTTP/1.1"
>>> pattern = re.compile(r"^([A-Z]+)\s+(\S+)\s+([A-Z0-9\/\.]+)$")
>>> m = pattern.match(status)
>>> m.groups()
('HEAD', '/foo', 'HTTP/1.1')
```

https://docs.python.org/3/howto/regex.html