Web Science:
Intro to Python
(Part 1 - Overview and Basics)

CS 432/532

Old Dominion University

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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 (no `{ }`)
- 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

Differences with C/C++ Syntax

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

Expression vs. Statement

Expression

- *Represents* something
- Python *evaluates* it
- Results in a *value*

- Examples:

```
"Hello" + " " + "World!"
```

```
(5*3)-1.4
```

Statement

- *Does* something
- Python *executes* it
- Results in an *action*

- Examples:

```
print("Hello World!")
```

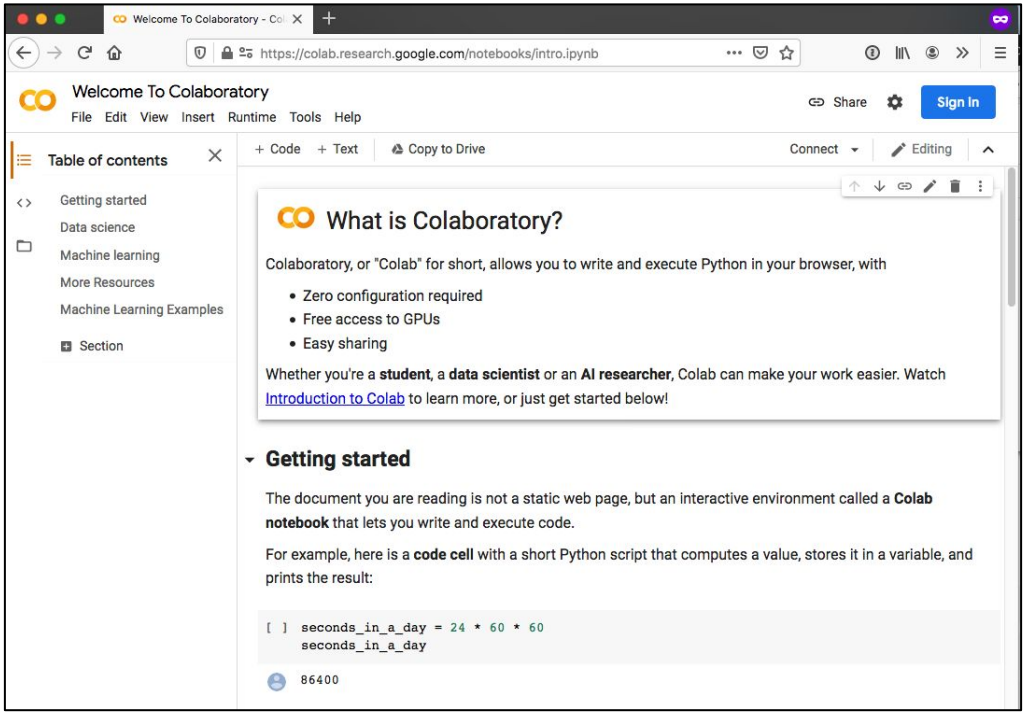
```
import os
```

Rule of Thumb: If you can print it or assign it to a variable, it's an expression. If you can't, then it's a statement.

Accessing the Python Interpreter

- Run locally on your own computer
  - download and install from Welcome to Python.org
- Login to ODU-CS Linux server
  - `ssh linux.cs.odu.edu`
  - or, use PuTTY to login to linux.cs.odu.edu (see Dr. Zeil's CS 252 notes, "Logging In")
- Google Colab Notebooks

Google Colab Notebooks



Ref: [Google Colab notebooks]

Code examples for the rest of the slide set are also in a Google Colab notebook

Interactive Python Shell

```
$ python3
Python 3.6.9 (default, Apr 18 2020, 01:56:04)
[GCC 8.4.0] 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)
[...]
>>> print("Hello World!")
Hello World!
>>> 2 + 3 * 4 / 5
4.4
>>> exit
Use exit() or Ctrl-D (i.e. EOF) to exit
>>> exit()
$
```

On CS Linux machines, use **python3** instead of python

Make sure you're using Python 3, not Python 2

Simple Data Types

- **Integer:** 7
- **Float:** 87.23

- **Boolean:** `False`, `True`

- **String:** `"abc"`, `'abc'`
- **Bytes:** `b"abc"`, `b'abc'`

String vs. Bytes

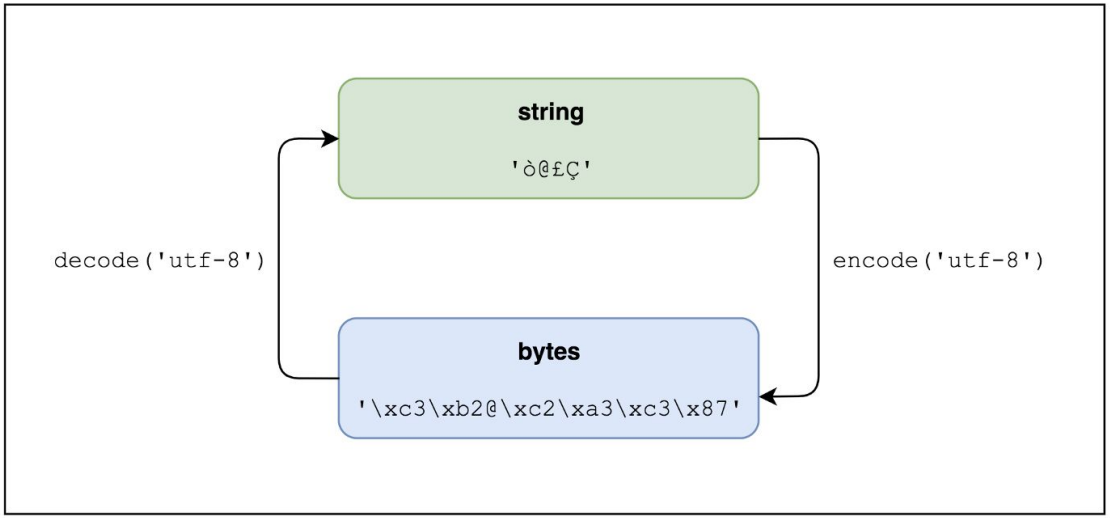
- Bytes object is a sequence of bytes
- String is a sequence of characters that must be encoded (often in Unicode, UTF-8)

```
>>> type("Hello")
<class 'str'>

>>> type(b"Hello")
<class 'bytes'>
```

`bytes` and `str` instances can't be used together with operators like `>` and `+`

Ref: Strings, Unicode, and Bytes in Python 3: Everything You Always Wanted to Know

Decoding Bytes, Encoding Strings



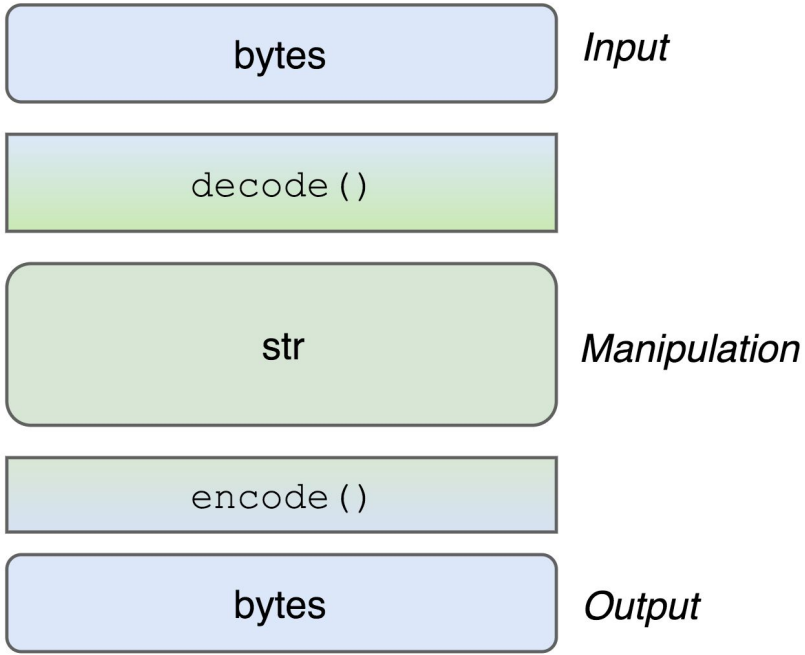

```
>>> b"Hello".decode()
'Hello'

>>> "Hello".encode()
b'Hello'
```

Ref: Strings, Unicode, and Bytes in Python 3: Everything You Always Wanted to Know

Manipulating Strings

"Unicode Sandwich"

"Bytes on the outside, unicode on the inside, encode/decode at the edges."



Ref: [Strings, Unicode, and Bytes in Python 3: Everything You Always Wanted to Know]

String

- Concatenation: `"Python"+"Rocks"` → `"PythonRocks"`
- Repetition: `"Python" * 2` → `"PythonPython"`
- Size: `len("Python")` → `6`
- Index: `"Python"[2]` → `'t'`
- Slicing: `"Python"[2:4]` → `"th"`
  `"Python"[:4]` → `"Pyth"`
- Search: `"th" in "Python"` → `True`
- Comparison: `"Python" < "ZOO"` → `True`
  (lexicographically)

Compound Data Types

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

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)`
  - Returns the length of X, which is 6

List

```
>>> mylist.reverse()
```
→ Reverse elements in list

```
>>> mylist.append(x)
```
→ Add element to end of list

```
>>> mylist.sort()
```
→ Sort elements in list ascending order

```
>>> mylist.index('a')
```
→ Find first occurrence of 'a'

```
>>> mylist.pop()
```
→ Removes last element in list

Ref: Python documentation, "More on Lists"

List

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

```
>>> unsorted = [32, 18, 17, 2, 5]
>>> unsorted.sort()
>>> unsorted
[2, 5, 17, 18, 32]
```

Tuple

```
>>> X = (0, 1, 'a', 4, 3)
```

- Creates a pre-populated list of fixed size 5

```
>>> print(X[3])
4

>>> X[0] = 'b'
```

Lists vs. Tuples

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

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-51-24d6d5b10aa9> in <module>()
----> 1 X[0] = 'b'

TypeError: 'tuple' object does not support item assignment
```

Ref: Python documentation, "Tuples and Sequences"

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

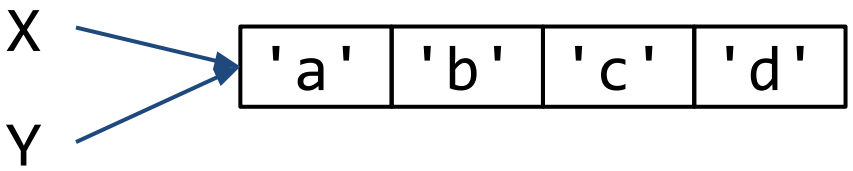
- `dict = { "fish": 12, "cat": 7}`
- `'dog' in dict` *Is 'dog' a key?*
- `dict.keys()` *Gets a list of all keys*
- `dict.values()` *Gets a list of all values*
- `dict.items()` *Gets a list of key-value tuples*
- `dict["fish"] = 14` *Assignment*

Ref: Python documentation, "Dictionaries"

Variables

- Everything is an object
- Assignment = reference
- No need to declare
- No need to assign
- Not strongly typed

```
>>> X = ['a', 'b', 'c']
>>> Y = X
>>> Y.append('d')
>>> print(X)
['a', 'b', 'c', 'd']
```



Comments

```
# This creates and populates a list
mylist = [2,5,3,7,1,8,12,4]

# This prints out Hello World!
print("Hello World!")
```

Web Science:
Intro to Python
(Part 2 - I/O and Conditionals)

CS 432/532

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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

Ref: Python documentation, "Reading and Writing Files"

Manipulating Files

- `readline()` - reads a line from file
- `readlines()` - reads all the file as a list of lines
- `read()` - reads all the file as one string

Loop Over a File Iterator

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

>>> for line in f:
        print(line)
```

File Write

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

File handle

Name of the file

Mode

```
>>> 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

Conditional

- 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)
```

`range(start=0, stop, step=1)` - generates integer numbers between the given start and stop

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

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

`in` - can be used in a loop to iterate through a list or in a conditional to test if a specific value is in a list

`not in` - can be used in a conditional to test if a specific value is *not* in a list

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!
```

Note the print statement here. It uses `{}` to denote where the result should appear and the `str.format()` function to format the variable.

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

```
>>> myList = ['hany','john','smith','aly','max']
>>> 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

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

→This will print all names except "aly"

Web Science:
Intro to Python
(Part 3 - Functions and Modules)

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Find the Largest 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 largest number is {}".format(maxnum))
```

Note the print statement here. It uses `{}` to denote where the result should appear and the `str.format()` function to format the variable.

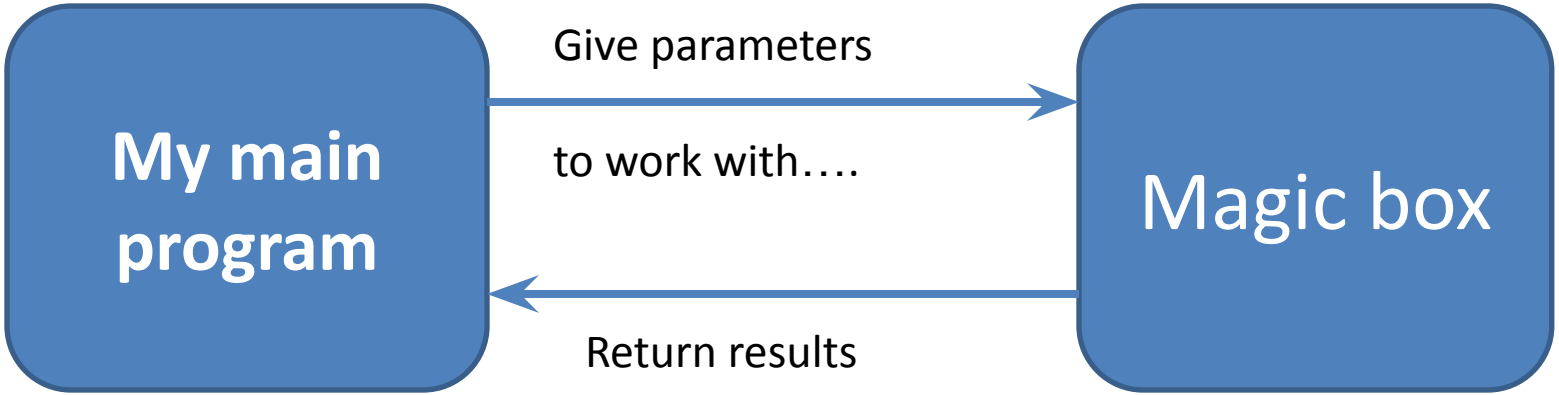
Functions

- 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_function(parameters):
    do stuff
```



Back to the example...

```
mylist = [2,5,3,7,1,8,12,4]

maxnum = getMaxNumber(mylist)

print("The largest 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
```

Is Anything Wrong with getMaxNumber()?

```
>>> getMaxNumber([3, 7, 1])
7

>>> getMaxNumber([3, -7, 1])
3

>>> getMaxNumber([-3, -7, -1])
0
```

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

New getMaxNumber()

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

>>> getMaxNumber([-3, -7, -1])
-1
```

For this example, there turns out to already be a built-in function to find the largest number in a list (max). getMaxNumber isn't really needed.

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 Can Return Multiple Values

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

Calling a Multi-Value Function

```
mylist = [2,5,3,7,1,8,12,4]
maxnum, idx = getMaxNumberAndIndex(mylist)
print("The largest number is {} and its index is {}" .
format(maxnum, idx))

The largest number is 12 and its index is 6
```

Note the print statement here. Now we have two {} instances. The variables are separated by a comma in the `str.format()` function.

Modules

- Python contains lots of modules with useful functions.

- Use the `import` statement to access the functions available in a module

Ref: Python Module Index

Module Example

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

Or

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

Or

```
>>> from math import sqrt as sq
>>> x = sq(25.0)
```

Web Science:
Intro to Python
(Part 4 - Running Python, Error Handling)

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Python Files

Python files end with `.py`

To execute a Python file named `myprogram.py`

```
$ python myprogram.py
```

On ODU-CS Linux machines, use `python3` instead of `python` (use Python version 3, not version 2)

```
$ python3 myprogram.py
```

Remainder of the slides will assume we're on ODU-CS Linux and will use `python3`

```
$ python --version
Python 2.7.17

$ python3 --version
Python 3.6.9
```

Python Scripts

- Scripts can be run without using the python3 command

1

```
#!/usr/bin/python3
# myprogram.py

print ("Hello World!")
```

```
$ which python3
/usr/bin/python3
```

2

```
$ chmod a+x myprogram.py
$ ls -l myprogram.py
-rwxr-xr-x 1 mweigle proxy 58 Jun  4 11:21 myprogram.py*
```

3

```
$ ./myprogram.py
Hello World!
```

Command-Line Arguments

- To access command line arguments:
  `import sys`

```
$ ./testargs.py weigle 432 532
```

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

  `len(sys.argv)` - returns the number of arguments

  `sys.argv[0]` - holds the name of the script

Ref: sys — System-specific parameters and functions — Python 3.8.5 documentation

Command-Line Arguments

```
#!/usr/bin/python3
# testargs.py

import sys

print ("{} is the name of the script." . format(sys.argv[0]))
print ("There are {} arguments: {}" . format(len(sys.argv), str(sys.argv)))

for ind, arg in enumerate(sys.argv):
     print ("[{}]: {} {}".format(ind, arg, sys.argv[ind]))
```

```
$ ./testargs.py weigle 432 532
./testargs.py is the name of the script.
There are 4 arguments: ['./testargs.py', 'weigle', '432', '532']
[0]: ./testargs.py ./testargs.py
[1]: weigle weigle
[2]: 432 432
[3]: 532 532
```

Error Handling

What happens when you have an error?

```
>>> sum_grades = 300
>>> num_students = input()
>>> average = sum_grades / int(num_students)
```

What if the user entered 0?

Error Handling

What happens when you have an error?

```
>>> sum_grades = 300
>>> num_students = input()
0
>>> average = sum_grades / int(num_students)
   ZeroDivisionError: division by zero
```

Exception Handling

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

Exception Handling

```
try:
 average = sum_grades / int(num_students)
except ZeroDivisionError:
 # This catches if a number was divided by zero
 print("You tried to divide by zero!")
 average = 0
```

Exception Handling

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

Automated Testing with doctest

```
# max_num.py

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()
```

```
$ python3 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.
```

Ref: [doctest — Test interactive Python examples — Python 3.8.5 documentation]

Web Science:
Intro to Python
(Part 5 - Regular Expressions and Web Libraries)

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Regular Expressions

- Access functions with `import re`
- Describe the regular expression pattern with `compile()`
- Apply the pattern starting at the beginning of a string with `match()`
- `[]` specifies a *character class*, range of characters to match
  - `[abc]` matches any of the characters ‘a’, ‘b’, or ‘c’
  - `[^abc]` matches any character ***NOT*** ‘a’, ‘b’, or ‘c’
- Shortcuts to particular classes
  - `\d` `[0-9]` `\D` `[^0-9]`
  - `\s` `[ \t\n\r\f\v]` (any whitespace) `\S` (non-whitespace)
  - `\w` `[a-zA-Z0-9_]` (any alphanumeric) `\W` (non-alphanumeric)

Ref: Regular Expression HOWTO — Python 3.8.5 documentation

Regular Expressions

- To repeat patterns
  - * matches 0 or more times
  - + matches 1 or more times

- To specify position in the line
  - ^ requires start of the line
  - $ requires end of the line

- Divide matches into groups with ( )

Ref: Regular Expression HOWTO — Python 3.8.5 documentation

Regular Expression Example

```
HEAD /foo HTTP/1.1
```

```
^([A-Z]+)\s+(\S+)\s+([A-Z0-9\/\.]+)$
```

`^([A-Z]+)`	1 or more capital letters at the beginning of line
`\s+`	1 or more whitespace character
`(\S+)`	1 or more non-whitespace character
`\s+`	1 or more whitespace character
`([A-Z0-9\/\.]+)$`	1 or more letters, numbers, /, or . at the end of the line

Regular Expressions

```
>>> import re

>>> req = "HEAD /foo HTTP/1.1"

>>> pattern =
 re.compile(r"^([A-Z]+)\s+(\S+)\s+([A-Z0-9\/\.]+)$")

>>> m = pattern.match(req)

>>> m.groups()
('HEAD', '/foo', 'HTTP/1.1')
```

`match()` returns None if no match is found

`groups()` returns a tuple containing all of the subgroups

Ref: Regular Expression HOWTO — Python 3.8.5 documentation Online regex tester: https://regex101.com/

Python Libraries: requests

The de facto standard for making HTTP requests in Python

```
import(requests)
response = requests.get('http://example.com')
```

Response headers and body are all stored in `response`

Refs: Requests: HTTP for Humans™ — Requests 2.24.0 documentation
Python's Requests Library (Guide) – Real Python

requests: Response Headers

```
import requests
response = requests.get('http://example.com')

print ("Status Code: {}".format(response.status_code))
print ("URI: {}\n".format(response.url))

print ("Headers: {}\n".format(response.headers))
print ("Date: {}".format(response.headers['Date']))
print ("Content-Type: {}".format(response.headers['Content-Type']))
print ("Content-Length: {}".format(response.headers['Content-Length']))
```

Refs: Python's Requests Library (Guide) – Real Python
redirection: Requests documentation, "Redirection and History"

requests: Request Parameters

```
import requests
response = requests.get('http://google.com/search', params={'q': 'LSU'})

print ("URI requested: {}".format(response.request.url))
print ("Status Code: {}\n".format(response.status_code))

# split the string into a list, one line per element
lines = response.text.splitlines()

# use loop to only print first 5 lines of the response
for i in range(5):
 print(lines[i])
```

Ref: Python's Requests Library (Guide) – Real Python

Beautiful Soup: HTML/XML Parser

```
from bs4 import BeautifulSoup
import requests

response = requests.get('http://google.com/search', params={'q': 'LSU'})

soup = BeautifulSoup(response.text)
for links in soup.find_all('a'):
  print(links.get('href'))
```

Refs: Beautiful Soup Documentation — Beautiful Soup 4.9.0 documentation
Beautiful Soup 4 Python, PythonForBeginners

Objectives

- Explain the differences between Python and C/C++ syntax.
- Execute a simple Python on the ODU-CS Linux server and in a Google Colab notebook.
- Describe the differences between a tuple, list, and dictionary.
- Write a Python program that accepts command-line arguments.
- Write a Python program that uses the requests library to access a webpage.
- Write a Python program that uses the BeautifulSoup library to extract all of the links in a webpage.