Python
For Data Science

Course Infrastructure

- Python 3
  - Develop Scripts
  - Interactive Shell
- Jupyter - would be preffered way
  - Effective to learn using Pandas, Numpy, Matlab

Topics

- Hello Python
- Comments
- Mathematics
- Variables
- Data Types
- Making Decisions
- Strings
- Python Lists
- For, While - Loops
- Lists Revisits
- Handling Errors
- Functions
- Modules
- Packages
- Dictionaries
- Classes
- Iterators
- String Formatting
- Regular Expressions

Hello to Python

```
#!/usr/bin/python3
print ("Hello \"World")
print ('Hello World')
print ("Hello, 'My Dear Friend'")
print ('Hello, "My Dear Friend"')
print ("One", "Two")
```

hello.py

output

```
Hello "World
Hello World
Hello, 'My Dear Friend'
Hello, "My Dear Friend"
One Two
```

Hello to Python (Cont...)

```
#!/usr/bin/python3

print("""
One - Hello
two - Python
three - Data Science
""")

print ("One", "Two", 'One-1', 'Two-2')

print ("I am first line\nI am second line")
```

output

```
One - Hello
two - Python
three - Data Science

One Two One-1 Two-2
I am first line
I am second line
```

hello_multiple.py

Assignment - 1

- Write “hello_datascience.py” Script
- It should print following output

```
Hello to Data Science
This is:

- Python Course
- Actually This is Data Science Course
```

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Comments

```
#!/usr/bin/python3

#this is a comment in Python

print ("Hello World") #This is also a comment in Python

""" This is an example of a multiline
comment that spans multiple lines
...
"""

print ("Let me try triple quotes")
'''
I am also comment
in muliple lines

'''
```

comments.py

output

```
Hello World
Let me try triple quotes
```

Mathematics

Python is perfectly suited to do Mathematics

- addition +
- subtraction -
- multiplication *
- division /

There is also support for more advanced operations such as

- Exponentiation **
- Modulo: %

Mathematics (Cont...)

```
#!/usr/bin/python3
# Addition and subtraction
print(5 + 5)
print(5 - 5)

# Multiplication and division
print(3 * 5)
print(10 / 2)

# Exponentiation
print(4 ** 2)

# Modulo
print(18 % 7)
```

```
10
0
15
5.0
16
4
```

mathematics.py

Assignment 2

Suppose you have Rs 1000. You have invested that with a 10% return per year scheme

After one year, you earnings = $1000 \times 1.1 = 1100$

After two years, earnings = $1000 \times 1.1 \times 1.1 = 1210$

- How much money you end up earning after 5 years?
- How much money you end up earning after 10 years?

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variables

```
#!/usr/bin/python3

counter = 1000                  # An integer assignment
miles   = 1050.0                # A floating point
name    = "Hari Sadu"           # A string

print (counter)
print (miles)
print (name)

a = b = c = 1

print (a)
print (b)
print (c)

a, b, c = 1, 2, "john"

print (a)
print (b)
print (c)

#BMI - Body Mass Index = weight/(height)^2
weight = 61.0
height = 1.79
bmi = weight / height ** 2
```

```
1000
1050.0
Hari Sadu
1
1
1
1
2
john
19.038107424861895
<class 'float'>
```

variables.py

Assignment - 3

- Create a variable *savings* equal to 1000
- Create a variable *interest*, equal to 1.10.
- Use *savings* and *interest* to calculate the amount of money you end up earning with after 8 years.
- Store the result in a new variable, *earnings*
- Print out the value of *earnings*

Word on Data Types

- Numbers
  - Int
  - float
- String
- Boolean - True, False
- List
- Tuple
- Dictionary

Making Decisions

```
#!/usr/bin/python3
# If the number is positive, we print an appropriate message

num = 3
if num > 0:
    print(num, "is a positive number.")
print("This is always printed.")

num = -1
if num > 0:
    print(num, "is a positive number.")
print("This is also always printed.")
```

```
3 is a positive number.
This is always printed.
This is also always printed.
```

if_demo.py

Making Decisions (Cont...)

```
#!/usr/bin/python3
# Program checks if the number is positive or negative
# And displays an appropriate message

num = 3

# Try these two variations as well.
# num = -5
# num = 0

if num >= 0:
    print("Positive or Zero")
else:
    print("Negative number")
```

```
Positive or Zero
```

if_else_demo.py

Making Decisions (Cont...)

```
#!/usr/bin/python3
# In this program,
# we check if the number is positive or
# negative or zero and
# display an appropriate message

num = 3.4

# Try these two variations as well:
# num = 0
# num = -4.5

if num > 0:
    print("Positive number")
elif num == 0:
    print("Zero")
else:
    print("Negative number")
```

```
Positive number
```

if_elif_demo.py

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Strings

- Strings in Python are identified as a contiguous set of characters represented in the quotation marks.
- Python allows for either pairs of single or double quotes.
- Subsets of strings can be taken using the slice operator ([ ] and [:])
    - with indexes starting at 0 in the beginning of the string and working their way from -1 at the end.

OPERATIONS

- Concatenation +
- Repetition with the help of asterisk *

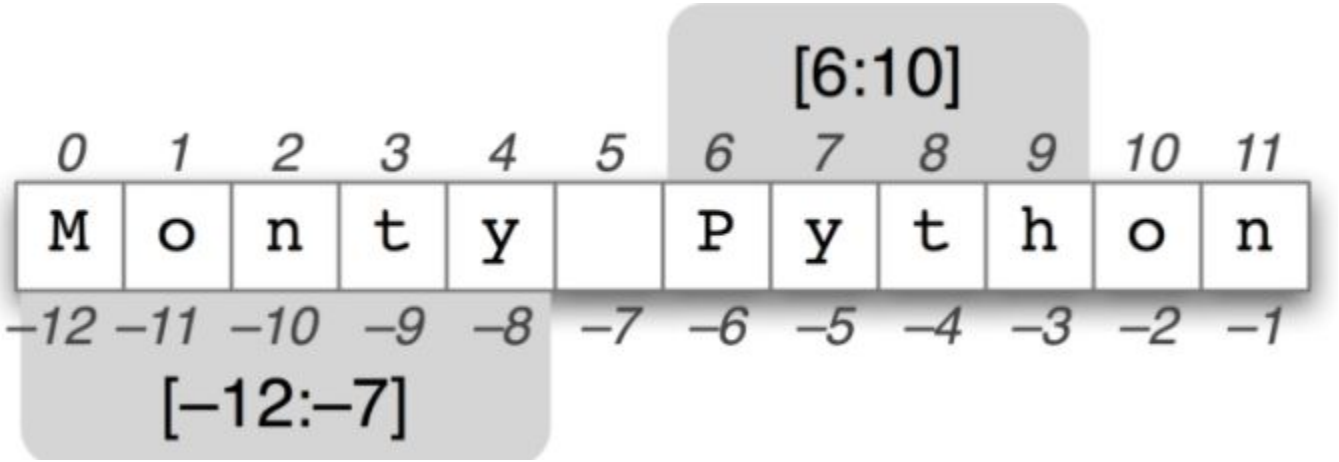
Strings (Cont...)

```
#!/usr/bin/python3

str = 'Hello World!'

print (str)          # Prints complete string
print (str[0])       # Prints first character of the string
print (str[2:5])     # Prints characters starting from 3rd to 5th
print (str[2:])      # Prints string starting from 3rd character
print (str * 2)      # Prints string two times
print (str + "TEST") # Prints concatenated string
```

```
Hello World!
H
llo
llo World!
Hello World!Hello World!
Hello World!TEST
```

strings_demo.py

Strings (Cont...)




```
#!/usr/bin/python3

s = 'Hello World'
print (len(s))
print (type(s))

s = 'Monty Python'

print(s[6:10])
print(s[-12:-7])
```

```
11
<class 'str'>
Pyth
Monty
```

strings_len.py

Strings - Quiz

- What is the output when following statements is executed ?
  - >>>"a"+"bc"
  - >>>"abcd"[2:]
- What arithmetic operators cannot be used with strings ?
  - +, -, *, **
- What is the output when following code is executed ?
  - >>>print r"\nhello"
  - print '\x97\x98'
- What is the output when following code is executed ?
  - >>>str1="helloworld"
  - >>>str1[::-1]
- What is the output of the following?
  - print("xyyzxyzxzxyy".count('yy'))
  - print("xyyzxyzxzxyy".count('yy', 1))
  - print("xyyzxyzxzxyy".count('xyy', 0, 100))

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Python Lists

A list contains items separated by commas

and enclosed within square brackets ([])

```
#!/usr/bin/python3

list     = [ 'abcd', 786 , 2.23, 'john', 70.2 ]
tinylist = [123, 'john']


print (list )              # Prints complete list
print (list[0]  )          # Prints first element of the list
print (list[1:3] )         # Prints elements starting from 2nd till 3rd
print (list[2:] )          # Prints elements starting from 3rd element
print (tinylist * 2 )      # Prints list two times
print (list + tinylist )   # Prints concatenated lists

print (type(list))         # type
print(len(list))           # length
```

List is sequence

```
['abcd', 786, 2.23, 'john', 70.2]
abcd
[786, 2.23]
[2.23, 'john', 70.2]
[123, 'john', 123, 'john']
['abcd', 786, 2.23, 'john', 70.2, 123, 'john']
<class 'list'>
5
```

lists_demo.py

for - Loop

```
for <variable> in <sequence>:
        <statements>
else:
        <statements>
```

```
#!/usr/bin/python3

languages = ["C", "Java", "Perl", "Python", "Node.js", "JavaScript"]

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

```
C
Java
Perl
Python
Node.js
JavaScript
```

for_demo.py

for - loop (Cont...)

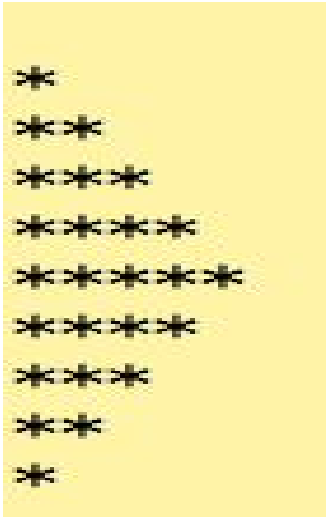
```
#!/usr/bin/python3

edibles = ["ham", "spam","eggs","nuts"]
for food in edibles:
    if food == "spam":
        print("No more spam please!")
        break
    print("Great, delicious " + food)
else:
    print("I am so glad: No spam!")
print("Finally, I finished stuffing myself")
```

```
Great, delicious ham
No more spam please!
Finally, I finished stuffing myself
```

for_demo_adv.py

Assignment - 4

Write a script to print pattern like below.



while - loop

```
#!/usr/bin/python3

count = 0
while (count < 9):
   print ('The count is:', count)
   count = count + 1

print ("Good bye!")
```

```
The count is: 0
The count is: 1
The count is: 2
The count is: 3
The count is: 4
The count is: 5
The count is: 6
The count is: 7
The count is: 8
Good bye!
```

while_demo.py

Assignment - 5

Write a program - to count “even” and “odd” numbers which are less than 50.

Revisit Lists

Accessing Lists

- n = len(L)
- item = L[index]
- seq = L[start:stop]
- seq = L[start:stop:step]
- seq = L[::2] # get every other item, starting with the first
- seq = L[1::2] # get every other item, starting with the second

Revisit Lists (Cont...)

```
for item in L:
    print (item)
```

```
for index, item in enumerate(L):
        print index, item
```

Revisit Lists (Cont...)

Other important Operations

- L.append(item)
- L.extend(sequence)
- L.insert(index, item)
- del L[i]
- del L[i:j]
- item = L.pop() # last item
- item = L.pop(0) # first item
- item = L.pop(index)
- L.remove(item)
- L.reverse()
- L.sort()
- out = sorted(L)

Quiz

- Q.1. Select the right options

```
names = ['Amir', 'Sahrukh', 'Chales', 'Dao']
print names[-1][-1]
```

So what's the output?

- i. A
- ii. r
- iii. Amir
- iv. Dao

- Q. 2. What gets printed?

```
names1 = ['Amir', 'Sahrukh', 'Chales', 'Dao']
names2 = names1
names3 = names1[:]

names2[0] = 'Alice'
names3[1] = 'Bob'

sum = 0
for ls in (names1, names2, names3):
    if ls[0] == 'Alice':
        sum += 1
    if ls[1] == 'Bob':
        sum += 10

print (sum)
```

Quiz (Cont...)

- Q. 3. What gets printed?

```
names1 = ['Amir', 'Sahrukh', 'Chales', 'Dao']
loc = names1.index("Edward")

print (loc)
```

- Q. 4. What's printed in following code?

```
names1 = ['Amir', 'Sahrukh', 'Chales', 'Dao']

if 'amir' in names1:
    print (1)
else:
    print (2)
```

- Q. 5. What gets printed?

```
numbers = [1, 2, 3, 4]
numbers.append([5,6,7,8])
print (len(numbers))
```

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Handling Errors

```
>>> while True:
...     age = int(input("Your age please:"))
... print(age)
  File "<stdin>", line 3
    print(age)
        ^
SyntaxError: invalid syntax
>>>
>>> while True;
  File "<stdin>", line 1
    while True;
              ^
SyntaxError: invalid syntax
>>>
>>> while True:
...     age = int (input("Your age please: "))
...     print (age)
...
Your age please: 22
22
Your age please: 45
45
Your age please: df
Traceback (most recent call last):
  File "<stdin>", line 2, in <module>
ValueError: invalid literal for int() with base 10: 'df'
>>>
```

```
>>> a
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'a' is not defined
>>> 1/0
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ZeroDivisionError: division by zero
>>> '10'+10
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: Can't convert 'int' object to str implicitly
>>>
```

Assignment - 6

Q 1 Develop a script to create list of lists. The element list should be factors of index of list.

(Note - We are yet to talk about “functions”)

Q 2. Develop a script to find the Highest Common Factor (HCF) of given two numbers.

Handling Errors(Cont..)

```
>>> try:
...     d = 1/0
... except:
...     print ("I could not divide 1 by 0")
...
I could not divide 1 by 0
>>>
>>> 1/0
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ZeroDivisionError: division by zero
>>> try:
...     d = 1/0
... except ZeroDivisionError:
...    print("Don't try to divide by 0")
...
Don't try to divide by 0
>>> try:
...     d = 10/2
... except ZeroDivisionError:
...    print("Don't try to divide by 0")
... else:
...    print("I am in else")
...
I am in else
>>> print(d)
5.0
>>>
```

Functions

Let us look at the problem of converting decimal number into binary number

```
11 = 5 * 2 + 1
 5 = 2 * 2 + 1
 2 = 2 * 1 + 0
 1 = 2 * 0 + 1

0 's binary expression is - 1
1 's binary expression is - 1

so 11 's binary expression is - 1011
```

```
def functionname( parameters ):
      "function_docstring"
      python statements - logic/code of function
      return [expression]
```

Functions

```
#!/usr/bin/python3

name = "Aegis"

def hellofunction(name=None):
    '''hello function'''
    if name:
       print ("Hello " + name )
    else:
      print ("Hello World!")

#hellofunction(name)
hellofunction()
```

function_hello.py

```
#!/usr/bin/python3
def decToBin(n):
    if n==0:
         return '0'
    else:
        return decToBin(int(n/2)) + str(n%2)

d = decToBin(11)

print (d)
```

function_dec2binary.py

Assignment - 7

Q 1 Develop a script to create list of lists. The element list should be factors of index of list.

(Note - We have talked about “functions”)

Q 2. Develop a script to find the Highest Common Factor (HCF) of given two numbers.

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Modules

- Modules are Python files with the .py extension.
- These files implement a set of functions and can have python statements.
- The modules can be imported from other modules using the import command.

The modules are best way to share your work, your tools with others.

Have a look at:

- https://docs.python.org/3/library/
- https://docs.python.org/2/library/

Modules (cont...)

```
#!/usr/bin/python3

def helloworld():
   print ("Hello World!")

def goodbye():
   print ("Good Bye Dear!")
```

hello_module.py

```
#!/usr/bin/python3
from hello_module import goodbye

print ("------I")
print (goodbye)

print ("------II")
goodbye()
```

test_hello_module.py

```
------I
<function goodbye at 0x7f538a412ea0>
------II
Good Bye Dear!
```

Modules (Cont...)

```
>>> import hello_module
>>> help(hello_module)
Help on module hello_module:

NAME
    hello_module

FUNCTIONS
    goodbye()

    helloworld()

FILE
    /datascience/hello_module.py


>>> dir(hello_module)
['__builtins__', '__cached__', '__doc__', '__file__', '__loader__', '__name
orld']
>>>
>>> from hello_module import goodbye
>>> help(goodbye)
Help on function goodbye in module hello_module:

goodbye()

>>> goodbye()
Good Bye Dear!
>>>
```

Modules (Cont ...)

```
>>> import sys
>>> sys.version
'3.5.2 (default, Nov 17 2016, 17:05:23) \n[GCC 5.4.0 20160609]'
>>> sys.version_info
sys.version_info(major=3, minor=5, micro=2, releaselevel='final', serial=0)
>>>
```

```
#!/usr/bin/python3
# import module sys to get the type of exception
import sys

randomList = ['a', 0, 2]

for entry in randomList:
    try:
        print("The entry is", entry)
        r = 1/int(entry)
        break
    except:
        print("Oops!",sys.exc_info()[0],"occured.")
        print("Next entry.")
        print()
print("The reciprocal of",entry,"is",r)
```

```
The entry is a
Oops! <class 'ValueError'> occured.
Next entry.

The entry is 0
Oops! <class 'ZeroDivisionError'> occured.
Next entry.

The entry is 2
The reciprocal of 2 is 0.5
```

one_more_exception.py

Module (Cont ...)

```
import subprocess
def disk (partition="/"):
     info = subprocess.call(["df", partition])
```

monitor.py

```
#!/usr/bin/python3

import subprocess
def disk (partition="/"):
     info = subprocess.call(["df", partition])

if __name__ == '__main__':
    import sys
    disk(sys.argv[1])
```

new_monitor.py

```
root@d5fc7cce17b6:/datascience# ./new_monitor.py /home
Filesystem     1K-blocks     Used Available Use% Mounted on
none            61890340 24866440  33856976  43% /
root@d5fc7cce17b6:/datascience#
root@d5fc7cce17b6:/datascience#
root@d5fc7cce17b6:/datascience#
root@d5fc7cce17b6:/datascience# python3
Python 3.5.2 (default, Nov 17 2016, 17:05:23)
[GCC 5.4.0 20160609] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from new_monitor import disk
>>> disk("/home")
Filesystem     1K-blocks     Used Available Use% Mounted on
none            61890340 24866440  33856976  43% /
```

Packages

- Help structure Python's module namespace by using "dotted module names".
  - The module name *package_a.mod_b* designates a submodule named *mod_b* in a package named *package_a*.
- Use of dotted module names saves the developers of multi-module packages from having to worry about each other's global variable names.

Let us assume we have the following directory structure. Here, hello.py & monotor.py are same modules described in *Module* section, and init.py is an empty file:

Packages (Cont …)

```
mypackage
|-- __init__.py
|-- hello_module.py
`-- monitor.py

0 directories, 3 files
```

init.py helps Python to treats this directory (*/mypackage*) as package directory.

```
>>> from mypackage import hello
>>> from mypackage import monitor
>>> dir(monitor)
['__builtins__', '__cached__', '__doc__', '__file__', '__loader__', '__
s']
>>> dir(hello)
['__builtins__', '__cached__', '__doc__', '__file__', '__loader__', '__
orld']
>>> hello.helloworld()
Hello World!
>>> monitor.disk("/home")
Filesystem     1K-blocks     Used Available Use% Mounted on
none            61890340 24866440  33856976  43% /
>>>
```

Assignment - 8

Q1. Create Package - which has modules to

- Factors of Number
- Calculate HCF
- Calculate the Factorial

Dictionaries

Also known as:

- *Associate Array*
- *Map*
- *Hash Map*
- *Unordered Map*

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Dictionaries (Cont …)

```
#!/usr/bin/python3

d1 = {}
print ("----------I")
print (type(d1))

d2 = {'one': 1, 'two':2}
print ("----------II")
print (d2)
print ("----------III")
print (type(d2))

d3 = dict(one=2, three=4)
print ("----------IV")
print (d3)
print (type(d3))

d4 = dict([(1, 2), (3, 4)])
print ("----------V")
print (d4)

d5 = dict({1:2, 3:4})
print ("----------V")
print (d5)
```

```
----------I
<class 'dict'>
----------II
{'one': 1, 'two': 2}
----------III
<class 'dict'>
----------IV
{'one': 2, 'three': 4}
<class 'dict'>
----------V
{1: 2, 3: 4}
----------V
{1: 2, 3: 4}
```

dictionaries.py

Dictionaries (Cont ...)

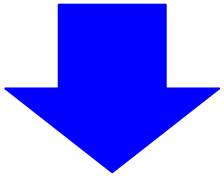
- d.clear()
- d.copy()
- del k[d]
- dict.fromkeys(seq[, value])
- iteration/accessing elements of dictionaries
- for key in my_dictionary:
- for key, value in my_dictionary.items():
- for value in my_dictionary.values():
- iter(d)
- len(d)
- d.keys()
- d.values()
- d.items()

Assignment - 9

- Create a List - "A", elements are integers. List may have repeated elements
- Create new "B", which has same element from "A" but all elements of "B" are Unique Elements
- Develop a function - to take generic list and return sorted, unique element list (we are still talking about integers)

Caching or Memoization

```
def some_function (arg1, arg2, arg3,..., argN):
        result = some computation involving arg1, arg2, arg3, ... argN
        return result
```



```
catche = {}
def some_function_with_catching(arg1, arg2, arg3, ..., argN):
        key = str(arg1) + str(arg2) + str(arg3) + .... + str(argN)
        if key in cache:
              return catche[key]
        else:
             result = same computation involving arg1, arg2, arg3, ..., argN
             catche[key]=result
             return result
```

Fibonacci Numbers

The Fibonacci Sequence is the series of numbers:

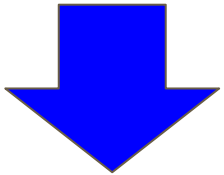
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, ...

The next number is found by adding up the two numbers before it.

- The 2 is found by adding the two numbers before it (1+1)
- The 3 is found by adding the two numbers before it (1+2),
- And the 5 is (2+3),
- and so on!

Caching or Memoization - Fibonacci Numbers

```
def fib(n):
    return n if n < 2 else fib(n-2) + fib(n-1)
```



```
__fib_cache = {}
def fib(n):
    if n in __fib_cache:
        return __fib_cache[n]
    else:
        __fib_cache[n] = n if n < 2 else fib(n-2) + fib(n-1)
        return __fib_cache[n]
```

Topics

- Hello Python
- Comments
- Mathematics
- Variables
- Data Types
- Making Decisions
- Strings
- Python Lists
- For, While - Loops
- Lists Revisits
- Handling Errors
- Functions
- Modules
- Packages
- Dictionaries
- **Classes**
- **Iterators**
- **String Formatting**
- **Regular Expressions**

Class

```
#!/usr/bin/python3
class MyClass(object):
    variable = "myvalue"

    def function(self):
        print("This is a message inside the class.")


myobj = MyClass()

print (type(myobj))
print (myobj.variable)


yourobj =  MyClass()
print (yourobj.variable)

yourobj.variable = "yourvalue"

print (yourobj.variable)
yourobj.function()
```

```
<class '__main__.MyClass'>
myvalue
myvalue
yourvalue
This is a message inside the class.
```

my_class.py

Class (Cont …)

- Classes are essentially a template to create your objects.
- init is the constructor for a class.
  - The self parameter refers to the instance of the object

```
#!/usr/bin/python3
class MyClass:
    variable = 'myvalue'
    def __init__(self, value = None):
        if value:
           self.variable = value


    def function(self):
        print("This is a message inside the class.")

    def  __repr__ (self):
         return "I am representation"

myobj = MyClass("Hello")

print (type(myobj))
print (myobj.variable)

print (myobj)
```

```
<class '__main__.MyClass'>
Hello
I am representation
```

my_advance_class.py

Class (Cont …)

```
class Person(object):
    def __init__(self, name, age):
          self.name = name
          self.age  = age

    def __repr__(self):
        return "Name: %s , Age: %d \n"  % (self.name, self.age)
```

Person.py

```
#!/usr/bin/python3
from  Person import  Person


def byAge(Person):
   return Person.age

p1  = Person("Doland Trump", 70)
p2  = Person("Barack Obama", 55)
p3  = Person("G Bush", 62)
p4  = Person("Bill Clinton", 54)
p5  = Person("Ronald Reagan", 77)



presidents  = [p1, p2, p3, p4, p5]

print (presidents)

sorted_presidents = sorted(presidents,  key=byAge)

print  (sorted_presidents)
```

sort_person.py

```
[Name: Doland Trump , Age: 70
, Name: Barack Obama , Age: 55
, Name: G Bush , Age: 62
, Name: Bill Clinton , Age: 54
, Name: Ronald Reagan , Age: 77
]
[Name: Bill Clinton , Age: 54
, Name: Barack Obama , Age: 55
, Name: G Bush , Age: 62
, Name: Doland Trump , Age: 70
, Name: Ronald Reagan , Age: 77
]
```

Day - Two

Topics

- Iterators
- Lists
- Numpy
- Interacting with Files
- Getting Data from Internet
- Regular Expressions
-

Assignment - 10

- Create Class - "City"
- Attributes
  a. Population
  b. Country
- Develop Script - to sort Cities (City instances) by Population
- Add GDP to City Class
  a. sort by GDP

Revisit Iterators

Python iterator objects are required to support two methods while following the iterator protocol.

- *iter* returns the iterator object itself. This is used in **for** and **in** statements.
- *next* method returns the next value from the iterator. If there is no more items to return then it should raise StopIteration exception.

Iterator Revisits (Cont …)

```
class EvenNumber(object):
    def __init__(self, low):
        if low % 2 != 0:
            self.current =  low + 1
        else:
            self.current = low

    def __iter__(self):
        'Returns itself as an iterator object'
        return self

    def __next__(self):
        'Returns the next value till cu
        self.current += 2
```

EvenNumber.py

Counter.py

```
class Counter(object):
    def __init__(self, low, high):
        self.current = low
        self.high = high

    def __iter__(self):
        'Returns itself as an iterator object'
        return self

    def __next__(self):
        'Returns the next value till current is lower t
        if self.current > self.high:
            raise StopIteration
        else:
```

```
5   6   7   8   9   10

2
4
6
```

test_counter_evennumber.py

String Formatting

- %s - String (or any object with a string representation, like numbers)
- %d - Integers
- %f - Floating point numbers
- %.f - Floating point numbers with a fixed amount of digits to the right of the dot.
- %x/%X - Integers in hex representation (lowercase/uppercase)
- New style {} & format function on strings

```
>>> name = "Donalt"
>>> age = 72
>>> print ("%s is %d years old " % (name, age))
Donalt is 72 years old
>>> mylist = [1,2,3]
>>> print("A list: %s" % mylist)
A list: [1, 2, 3]
>>>
```

```
>>> print ("The President {} is {} old".format(name, age))
The President Donalt is 72 old
>>>
```

String Formating (Cont …)

```
>>> print ("{:.2f}".format(1.123456))
1.12
```

Number	Format	Output	Description
3.1415926	{:.2f}	3.14	2 decimal places
3.1415926	{:+.2f}	+3.14	2 decimal places with sign
-1	{:+.2f}	-1.00	2 decimal places with sign
2.71828	{:.0f}	3	No decimal places
5	{:0>2d}	05	Pad number with zeros (left padding, width 2)
5	{:x<4d}	5xxx	Pad number with x's (right padding, width 4)
10	{:x<4d}	10xx	Pad number with x's (right padding, width 4)
1000000	{:,}	1,000,000	Number format with comma separator
0.25	{:.2%}	25.00%	Format percentage
1000000000	{:.2e}	1.00e+09	Exponent notation
13	{:10d}	13	Right aligned (default, width 10)
13	{:<10d}	13	Left aligned (width 10)
13	{:^10d}	13	Center aligned (width 10)

Revisit Lists

- Comprehensions
- Lambda Functions
- Map
- Filters

```
>>> squares = []
>>> for x in range(10):
...     sq = x ** 2
...     squares.append(sq)
...
>>>
>>> squares
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
>>>
```

Old Way

```
>>> new_style = [x ** 2 for x in range(10)]
>>> new_style
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
>>>
```

New Way

```
>>> for x in [1, 3, 4, 2, 5, 6]:
...     for y in [2, 3, 5, 4, 10]:
...         if x != y:
...             print ("(", x, y, ")")
...
( 1 2 )
( 1 3 )
( 1 5 )
( 1 4 )
```

Old Way

New Way

```
>>> [(x, y) for x in [1, 3, 4, 2, 5, 6]  for y in [2, 3, 5, 4, 10] if x != y]
[(1, 2), (1, 3), (1, 5), (1, 4), (1, 10), (3, 2), (3, 5), (3, 4), (3, 10), (4, 2), (4, 3), (
 4), (2, 10), (5, 2), (5, 3), (5, 4), (5, 10), (6, 2), (6, 3), (6, 5), (6, 4), (6, 10)]
>>>
```

Revisit Lists (Cont ...)

```
lambda arguments: expression
```

```
>>> sqr = lambda x: x ** 2
>>> sqr(10)
100
>>> sqr(15)
225
>>> multiplication = lambda x, y: x * y
>>> multiplication(7, 5)
35
>>> multiplication(10, 5000)
50000
>>>
```

The filter() function in Python takes in a function and a list as arguments. Function is evaluated for True value.

The map() function in Python takes in a function and a list. The new list has elements returned by function.

Revisited Lists (Cont ...)

```
>>> my_list = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 16, 34, 35, 33]
>>> new_list = list(filter(lambda x: (x %2 == 0), my_list))
>>> new_list
[2, 4, 6, 8, 10, 12, 16, 34]
>>>
```

```
>>> another_list = list(map(lambda x: x ** 2, my_list))
>>> another_list
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 144, 256, 1156, 1225, 1089]
>>>
```

Assignment -11

Q 1 Develop a script to create list of lists. The element list should be factors of index of list.

Q 2. Develop a script to find the Highest Common Factor (HCF) of given two numbers.

Use Lambda, Map, Filter to solve above

Numpy: Scientific Library for Data Science!

Numpy - Numerical Python

- ndarry: multi-dimensional array proving vectorized arithmetic operations
- Mathematical operations on entire array without having to use loops
- Tools to write, read data from disk, tools to work with memory-mapped files
- Linear Algebra, Random Number Generation, and Fourier Transform capabilities.
- Tools to integrate code with lower level languages like C, C++

Numpy (cont...)

Focus is on :

- Fast Vectorized Array Operations for data munging & Cleaning, subsetting, and filtering, transformation and any kind of computation.
- Common array operations - sorting, unique & set operations
- Statistics operations - aggregation, summarizing data
- Merging, joining data sets together
- Play with conditional logic (if-else)
- Grouping & manipulating

Data Used

	2012 - 100 meter Olympics Result			
	Time	Height (Inches)	Weight (Pounds)	Country
Usain Bolt	9.63	76.77	209.439	JAM
Yohan Blake	9.75	70.86	167.551	JAM
Justin Gatlin	9.79	72.83	182.984	USA
Tyson Gay	9.8	70.07	165.347	USA
Ryan Bailey	9.88	75.98	216.053	USA
Churandy Martina	9.94	70.07	163.142	NED
Richard Thompson	9.98	70.01	176.37	TTO
Asafa Powell	11.99	70.8	191.802	JAM

100_runners.csv

Revisit Lists - Count BMI List Way

```
#!/usr/bin/python3
# height in inches, weight in pounds
height = [76.77,  70.86,  72.83,  70.07,  75.98,  70.07,  70.01, 70.8]
weight = [209.439, 167.551, 182.984, 165.347, 216.053, 163.142, 176.37, 191.802]

m_height = [x * 0.0254 for x in height]
k_weight = [x * 0.453592 for x in weight]

#print (m_height)
#print (k_weight)

# kg/m^2

msqr_height = [x * x for x in m_height]
#print (msqr_height)

bmi  = [k_weight[i]/msqr_height[i] for i in range(len(msqr_height))]
print (bmi)
```

bmi_lists.py

```
#!/usr/bin/python3

import numpy as np

# height in inches, weight in pounds
height = [76.77,  70.86,  72.83,  70.07,  75.98,  70.07,  70.01, 70.8]
weight = [209.439, 167.551, 182.984, 165.347, 216.053, 163.142, 176.37, 191.802]

np_height = np.array(height)
np_weight = np.array(weight)


np_height_meters  = np_height  * 0.0254
np_weight_kgs = np_weight *  0.453592

#print (m_height)
#print (k_weight)

# kg/m^2

np_height_meters_sqr  = np_height_meters ** 2
#print (msqr_height)

bmi = np_weight_kgs / np_height_meters_sqr

print (bmi)
```

Importing Numpy Library

Creating Numpy Array - from List

Multiply each element of Numpy Array

Square each element

Divide each element

bmi_numpy.py

Numpy - A few Observations

```
>>> import numpy as np
>>> my_numpy = np.array([11.00, 12, 'numpy', True, False])
>>> type(my_numpy)
<class 'numpy.ndarray'>
>>> my_numpy
array(['11.0', '12', 'numpy', 'True', 'False'],
      dtype='<U32')
>>> my_list = [11.00, 12, 'numpy', True, False]
>>> type(my_list)
<class 'list'>
>>> my_list + my_list
[11.0, 12, 'numpy', True, False, 11.0, 12, 'numpy', True, False]
>>> my_numpy + my_numpy
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: ufunc 'add' did not contain a loop with signature matching types dtype('<U32') dtype('<U32') dtype('<U32')
>>> my_numpy_n = np.array([1, 2, 3])
>>> type(my_numpy_n)
<class 'numpy.ndarray'>
>>> my_numpy_n
array([1, 2, 3])
>>> my_numpy_n + my_numpy_n
array([2, 4, 6])
>>>
```

Numpy - Subsetting

```
>>> import numpy as np
>>> bmi = np.array([ 24.98460153,  23.46079266,  24.25439523,  23.67718338,  26.31235232, 23.36143414,  25.29895093,  26.9
005])
>>> type(bmi)
<class 'numpy.ndarray'>
>>> bmi[1]
23.460792659999999
>>> bmi[0]
24.984601529999999
>>> bmi[11]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: index 11 is out of bounds for axis 0 with size 8
>>> bmi > 24
array([ True, False,  True, False,  True, False,  True,  True], dtype=bool)
>>> bmi > 23
array([ True,  True,  True,  True,  True,  True,  True,  True], dtype=bool)
>>> bmi > 22
array([ True,  True,  True,  True,  True,  True,  True,  True], dtype=bool)
>>> bmi[bmi > 22]
array([ 24.98460153,  23.46079266,  24.25439523,  23.67718338,
        26.31235232,  23.36143414,  25.29895093,  26.90200005])
>>> bmi[bmi > 24]
array([ 24.98460153,  24.25439523,  26.31235232,  25.29895093,  26.90200005])
>>> bmi[bmi > 25]
array([ 26.31235232,  25.29895093,  26.90200005])
>>> bmi[bmi > 26]
array([ 26.31235232,  26.90200005])
>>> bmi[bmi > 26.9]
array([ 26.90200005])
>>>
```

Practice - One (Create Numpy Array)

- Import the **numpy** package as **np**
- Use **np.array()** to create a Numpy array from **m_runners**. Name this array **np_m_runners** Print out the **type** of **np_m_runners** to check that you got it right.

```
#          one.py

# This is 2012 Olympics Game 100 meter speed result
m_runners = [9.63, 9.75, 9.79, 9.80, 9.88, 9.94, 9.98, 11.99]

# Import the numpy package as np

# Create a Numpy array from m_runners: np_m_runners

# Print out type of np_m_runners

# Print np_m_runners
```

Practice Two - Count Hight

- Create a Numpy array from height. Name this new array np_height.
- Print np_height.
- Multiply np_height with 0.0254 to convert all height measurements from inches to meters. Store the new values in a new array, np_height_m.
- Print out np_height_m

```
#     #two.py
# Import numpy
import numpy as np

height = [76.77,  70.86,  72.83,  70.07,  75.98,  70.07,  70.01, 70.8]
# Create a Numpy array from height: np_height

# Print out np_height

# Convert np_height to m: np_height_m
# You need to multiply by  0.0254

# Print np_height_m
```

Practice Three - Count bmi

- Create a Numpy array from the weight list, height list with the correct units. Call them - np_weight_kg & np_height_m
- Use np_height_m and np_weight_kg to calculate the BMI of each player. Use the following equation: BMI=weight(kg)/height(m)^2
- Save the resulting numpy array as bmi.
- Print out bmi.

```
# three.py

# height in inches & weight in pounds
height = [76.77,  70.86,  72.83,  70.07,  75.98,  70.07,  70.01, 70.8]
weight = [209.439, 167.551, 182.984, 165.347, 216.053, 163.142, 176.37, 191.802]
# Import numpy
# Create array from height with correct units: np_height_m  - multiplication by  0.0254
# Create array from weight with correct units: np_weight_kg - multiplication by 0.453592
# Calculate the BMI: bmi  - use kg/m^2
# Print out bmi
```

Practice Four - Lightweight

- Create a boolean Numpy array: the element of the array should be True if the corresponding runners BMI is below 23. You can use the < operator for this. Name the array light.
- Print the array light.
- Print out a Numpy array with the BMIs of all runners whose BMI is below 23. Use light inside square brackets to do a selection on the bmi array.

```
# four.py
#height and weight are available as a regular lists
height = [76.77,  70.86,  72.83,  70.07,  75.98,  70.07,  70.01, 70.8]
weight = [209.439, 167.551, 182.984, 165.347, 216.053, 163.142, 176.37, 191.802]
# Import numpy

# Calculate the BMI: bmi
np_height_m = np.array(height) * 0.0254
np_weight_kg = np.array(weight) * 0.453592
bmi = np_weight_kg / np_height_m ** 2

# Create the light array
# Print out light
# Print out BMIs of all runners whose BMI is below 23
```

Practice Five - Match the Following

1

```
>>> demo = np.array([1, 2, 3, 4, 5, 6, 7, 8])
>>> demo>2
```

2

```
>>> demo = np.array([1, 2, 3, 4, 5, 6, 7, 8])
>>> demo[demo >5]
```

3

```
>>> a = np.array([1, 2, 3, True])
>>> b = np.array([False, 2, 3, 4])
>>> a + b
```

4

```
>>> demo = np.array([1, 2, 3, 4, 5, 6, 7, 8])
>>> demo[demo < 1]
```

A

```
array([6, 7, 8])
```

B

```
array([1, 4, 6, 5])
```

C

```
array([], dtype=int64)
```

D

```
array([False, False,  True,  True,  True,  True,  True,  True], dtype=bool)
```

Practice Six - Subsetting

- Subset np_weight: print out the element at index 5.
- Print out a sub-array of np_height: It contains the elements at index 3 up to and including index 6

#six.py
height = [76.77, 70.86, 72.83, 70.07, 75.98, 70.07, 70.01, 70.8]
weight = [209.439, 167.551, 182.984, 165.347, 216.053, 163.142, 176.37, 191.802]

N-Dimensional Arrays Numpy

- ndarray - generic multidimensional container for homogeneous data
- shape - tuple indicating size of each dimension
- dtype - an object indicating data type of the array

```
>>> import numpy as np
>>> data = ([0.1000, 0.1200, 0.1300, 0.1400], [0.2100, 0.2200, 0.2300, 0.2400])
>>> n_data = np.array(data)
>>> n_data.shape
(2, 4)
>>> n_data.dtype
dtype('float64')
```

2 rows, 4 columns

Additional Functions to Create ndarrays

- zeros
- ones
- empty

```
>>> o = np.zeros(5)
>>> print(o)
[ 0.  0.  0.  0.  0.]
>>> o.dtype
dtype('float64')
>>> o.size
5
>>> one = np.ones(7)
>>> print(one)
[ 1.  1.  1.  1.  1.  1.  1.]
>>> one.dtype
dtype('float64')
>>> one.shape
(7,)
>>> one.size
7
>>>
```

```
>>> e = np.empty(9)
>>> print(e)
[  6.90268625e-310   6.90268625e-310   2.03650144e-316   6.90264011e-310
   2.37151510e-322   2.37151510e-322   2.03589354e-316   6.90268625e-310
   2.03650381e-316]
>>> e.dtype
dtype('float64')
>>>
```

Additional Functions to Create ndarrays

```
>>> np.zeros((2, 3))
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
>>> np.zeros((2, 3, 1))
array([[[ 0.],
        [ 0.],
        [ 0.]],

       [[ 0.],
        [ 0.],
        [ 0.]]])
>>> np.ones((2, 3, 1))
array([[[ 1.],
        [ 1.],
        [ 1.]],

       [[ 1.],
        [ 1.],
        [ 1.]]])
>>> np.ones((2, 3))
array([[ 1.,  1.,  1.],
       [ 1.,  1.,  1.]])
```

```
>>> np.empty((3, 2, 1))
array([[[ 0.],
        [ 0.]],

       [[ 0.],
        [ 0.]],

       [[ 0.],
        [ 0.]]])
>>> np.empty((3, 2))
array([[ 0.,  0.],
       [ 0.,  0.],
       [ 0.,  0.]])
>>> np.empty((2, 5))
array([[  6.90268625e-310,   6.90268625e-310,   2.87311426e-317,
          1.97626258e-323,   1.85541175e-316],
       [  6.90268034e-310,   6.90267919e-310,   0.00000000e+000,
          0.00000000e+000,   0.00000000e+000]])
>>> np.empty((2, 2))
array([[  6.90268625e-310,   1.88584462e-316],
       [  6.90268053e-310,   5.30563263e-317]])
>>>
```

Operation between Arrays and Scalars

```
>>> my_array = np.array([[1.0, 2.0, 3.0], [4.0, 5.0, 6.0]])
>>> my_array.dtype
dtype('float64')
>>> my_array * my_array
array([[  1.,   4.,   9.],
       [ 16.,  25.,  36.]])
>>> my_array - my_array
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
>>> 1/my_array
array([[ 1.        ,  0.5       ,  0.33333333],
       [ 0.25      ,  0.2       ,  0.16666667]])
>>> my_array ** 2
array([[  1.,   4.,   9.],
       [ 16.,  25.,  36.]])
>>>
```

Basic Indexing and Slicing

```
>>> exp_array = np.arange(10)
>>> exp_array
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
>>> exp_array[5]
5
>>> exp_array[0]
0
>>> exp_array[2:5]
array([2, 3, 4])
>>> exp_array[2:5]=22
>>> exp_array
array([ 0,  1, 22, 22, 22,  5,  6,  7,  8,  9])
>>>
```

Basic Indexing and Slicing (cont...)

```
>>> exp_array = np.arange(10)
>>> exp_array[5]
5
>>> exp_array[2:5]
array([2, 3, 4])
>>> exp_array[2:5] = 29
>>> exp_array
array([ 0,  1, 29, 29, 29,  5,  6,  7,  8,  9])
>>> my_slice = exp_array[2:5]
>>> my_slice
array([29, 29, 29])
>>> my_slice[1] = 44
>>> my_slice
array([29, 44, 29])
>>> exp_array
array([ 0,  1, 29, 44, 29,  5,  6,  7,  8,  9])
>>> my_slice[:] = 400
>>> exp_array
array([  0,   1, 400, 400, 400,   5,   6,   7,   8,   9])
>>>
```

Basic Indexing and Slicing (cont...)

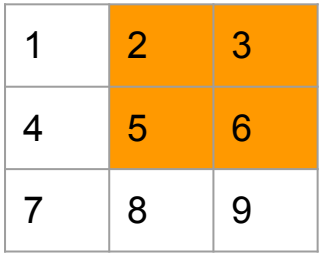
```
>>> import numpy as np
>>> arr2d = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
>>> arr2d[2]
array([7, 8, 9])
>>> arr2d[0][2]
3
>>>
```

axis 1

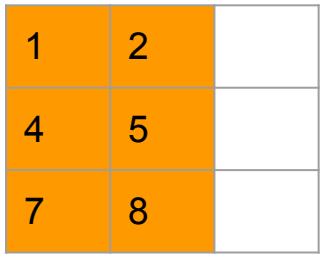
axis 0

	0	1	2
0	0,0	0,1	0,2
1	1,0	1,1	1,2
2	2,0	2,1	2,2

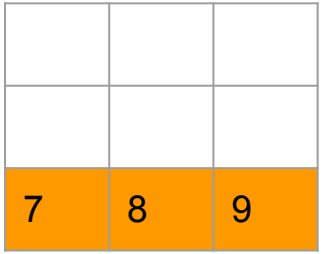
Basic Indexing and Slicing (cont...)



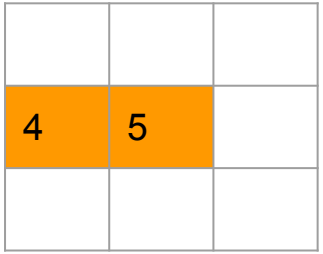

```
>>> arr2d[:2,1:]
array([[2, 3],
       [5, 6]])
```




```
>>> arr2d[:,:2]
array([[1, 2],
       [4, 5],
       [7, 8]])
```




```
>>> arr2d[2]
array([7, 8, 9])
>>> arr2d[2, :]
array([7, 8, 9])
>>> arr2d[2:, :]
array([[7, 8, 9]])
>>>
```




```
>>> arr2d[1,:2]
array([4, 5])
>>> arr2d[1:2,:2]
array([[4, 5]])
```

Interacting with Files

Open - function in Python

```
file_object = open ("filename", "mode")

Mode is one of the following:
   r  : Read mode which is used when the file is only being read
   w  : Write mode which is used to edit and write new information to the
        file (any existing files with the same name will be erased when this mode is activated)
   a  : Appending mode, which is used to add new data to the end of the file;
       that is new information is automatically amended to the end
   r+ : Special read and write mode, which is used to handle both actions when working with a file
```

Interacting with Files (Cont...)

```
#!/usr/bin/python3

f = open ('simple_data.txt', 'w')

f.write("Hello to writing data into file")
f.write("Line ------2")
f.write("Line ------3")
f.close()
```

simple_file_creation.py

simple_data.txt

```
Hello to writing data into fileLine ------2Line ------3
```

```
#!/usr/bin/python3

f = open('simple_data.txt', 'r')

print (f.read())
f.close()
```

simple_file_read.py

Interacting with Files (Cont...)

```
#!/usr/bin/python3

def do_stuff_that_fails():
     print("I actually failed to work")

def do_stuff_when_it_doesnt_work():
     print("Tried but it did not work")

try:
    with open('my_file_which_do_not_exist') as f:
        read_data = f.read()
        print (read_data)

        do_stuff_that_fails()
except (IOError, OSError) as e:
    do_stuff_when_it_doesnt_work()
```

good_deal.py

Getting Data from Internet

```
#!/usr/bin/python3
import urllib.request
import time

stocks_to_pull = ['AMD', 'BAC', 'MSFT', 'TXN', 'GOOG']

def pull_data_for_stock(stock):
    stock_file = stock + '.txt'
    url = 'http://chartapi.finance.yahoo.com/instrument/1.0/'+stock+'/chartdata;type=quote;range=1y/csv'
    print ("Data from URL: " + url)
    with urllib.request.urlopen(url) as f:
        source = f.read().decode('utf-8')

    split_source = source.split('\n')
    for line in split_source:
          saveFile = open(stock_file,'a')
          linetoWrite = line + '\n'
          saveFile.write(linetoWrite)

    print('Pulled', stock)
    print('...')
    time.sleep(.5)

if __name__=="__main__":
    for stock in stocks_to_pull:
        print ("working on " + stock)
        pull_data_for_stock(stock)
```

get_stock.py

Assignment - 12

Get data from -

https://web.williams.edu/Mathematics/sjmiller/public_html/317/DietProblemData.csv

assignment_url.txt

Regular Expressions

Let us define some rules to form some strings:

- Write a letter "a" at least once
- Append to this the letter "b" exactly five times
- Append to this the letter "c" any even number of times
- Optionally, write the letter "d" at the end

Examples of such strings are:

`aaaabbbbbccccd`

`aabbbbbcc`

...

Regular Expressions (Cont ...)

```
#!/usr/bin/python3
import re

pattern = 'Hello'
text = 'Hello Data Science Folks, How are you?'

match = re.search(pattern, text)

s = match.start()
e = match.end()

print('Found "{}" in "{}" from {} to {} ("{}")'.format(match.re.pattern, match.string, s, e, text[s:e]))
```

```
Found "Hello" in "Hello Data Science Folks, How are you?" from 0 to 5 ("Hello")
```

simple_match.py

Regular Expression (Cont …)

Python supports compilation of pattern - it's more efficient to compile the pattern and use it. The compile() function converts an expression string into a RegexObject.

```
#!/usr/bin/python3
import re

# Precompile the patterns
regexes = [ re.compile(p) for p in ['Hello', 'Donald'] ]
text = 'Hello DataScience folks, How are you doing today?'

print('Text: {!r}\n'.format(text))

for regex in regexes:
    print (type(regex))
    print('Seeking "{}" ->'.format(regex.pattern), end=' ')

    if regex.search(text):
        print('Matchig!')
    else:
        print('No, I am not matching')
```

```
Text: 'Hello DataScience folks, How are yo

<class '_sre.SRE_Pattern'>
Seeking "Hello" -> Matchig!
<class '_sre.SRE_Pattern'>
Seeking "Donald" -> No, I am not matching
```

simple_compiled.py

Regular Expression (Cont …)

```
#!/usr/bin/python3
import re

text = 'abbaaabbbbaaaaa'

pattern = 'ab'

for match in re.findall(pattern, text):
    print (type(match) )
    print ('Found "%s"' % match)
```

```
<class 'str'>
Found "ab"
<class 'str'>
Found "ab"
```

find_iter.py

```
<class '_sre.SRE_Match'>
Found "ab" at 0:2
<class '_sre.SRE_Match'>
Found "ab" at 5:7
```

```
#!/usr/bin/python3

import re

text = 'abbaaabbbbaaaaa'

pattern = 'ab'

for match in re.finditer(pattern, text):
    print (type(match))
    s = match.start()
    e = match.end()
    print ('Found "%s" at %d:%d' % (text[s:e], s, e))
```

find_all.py

Regular Expression (Cont ...)

There are infinitely many such strings which satisfy above rules.

Regular Expressions are merely a shorthand way of expressing these sets of rules

- Regex are text matching patterns described with a formal syntax
- The patterns which are executed on text as input to produce either matching subset or modified version of original text
- Regular Expression is kind of programming language itself
- "re" module provides this functionality in Python Programming

Your friendship with re will always add advantage to your skills if you ever need to deal with Text Processing in your project.

Regular Expression (Cont …)

A Few Rules: Commonly Used RegEx symbols

symbol	Meaning	Example Pattern	Example Matches
*	Matches Preceding Char, Subexpression, or bracked char 0 or more times	*ab*	aaaaaa, aaabbbb, bbbb
+	Matches Preceding Char, Subexpression, or bracked char 1 or more times	a+b+	aaaaab, aaabbbb, abbbb
[]	Matches any char within bracket	[A-Z]*	APPLE, CAPITAL,
()	A groupd subexpression	*(ab)*	aaabaab, abaaab
{m, n}	Matches the preceding character, subexpression, or bracketed chars between m and n times	a{2,3}b{2,3}	
[^]	Matches any single character that is not in the brackets	[^A-Z]*	aaple
		Matches any char, or subexpression, separated by	
.	Matches any single charector	b.d	bed, bzd, b$d
^	Beging of line	^a	apple, an,
|An Escape Char			
$	Used for end of line char	[A-Z]*[a-z]*$	ABCabc, zzzyz, Bob

Matching Codes

Code	Meaning
\d	a digit
\D	a non-digit
\s	whitespace (tab, space, newline, etc.)
\S	non-whitespace
\w	alphanumeric
\W	non-alphanumeric

Regular Expression (Cont …)

Mostly used functions from re module,

- compile(pattern, flags=0) – it compiles a regular expression pattern into a regular expression object, which can be used for matching using the match and search methods.
- match(pattern, string, flags=0) – if zero or more characters from the beginning of the string match, it returns a Match object, otherwise, it returns None.
- search(pattern, string, flags=0) – similar to match(), but it scans all the string, not only it's beginning.
- sub(pattern, repl, string, count=0, flags=0) - Return the string obtained by replacing the leftmost non-overlapping occurrences of the pattern in string by the replacement repl. repl can be either a string or a callable; if a string, backslash escapes in it are processed. If it is a callable, it's passed the match object and must return a replacement string to be used.

Regular Expression (Cont …)

```
#!/usr/bin/python3
import re

line = 'The   fox jumped   over    the        log'
pattern = re.compile('\s+')

line = re.sub(pattern, '_', line)
print (line)
```

```
The_fox_jumped_over_the_log
```

How about following expression?

```
re.sub('\s{2,}', ' ', line)
```

remove_multiple_spaces.py

Assignment - 11

- Remove starting spaces in line
- Remove ending spaces in line
- How about removing all digits from line?

Develop Regular Expression to extract numbers (float, integers) from given text string. The numbers can be in any of the following format

'10.5', '-10.5', '- 10.5', '+ .2e10', ' 1.01e-2', ' 1.01', '-.2', ' 456', ' .123'

Practice - Read Files & Regular Expression

- Declare “finish_time”, “year” Lists - empty lists
- Read File 100_meter.csv using Python (use **with**)
- Remove white-spaces with the help of regex
- Read Line by Line, Split Each lines at “,” (strings have split method)
- Append first element in year list & second element in finish_time list
- Handle empty elements, elements with strings
- Create “finish_time_np” & “year_np” as numpy arrays from “finish_time” and “year” lists

Data Visualization - Plotting

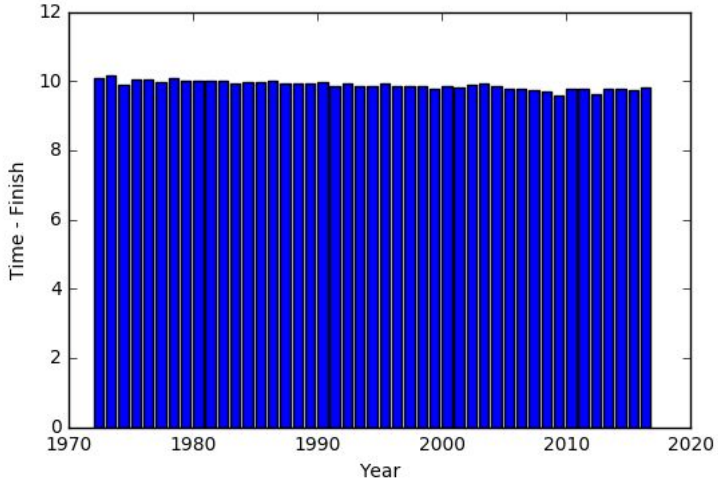
matplotlib.pyplot is a collection of command style functions that helps draw graphs

Types of Graph

- Bar Graphs
- Box and Whiskers (Boxplots)
- Frequency Distribution
- Histogram
- Line Graphs
- Pie Graphs
- Scatter Graphs
- Stemplots

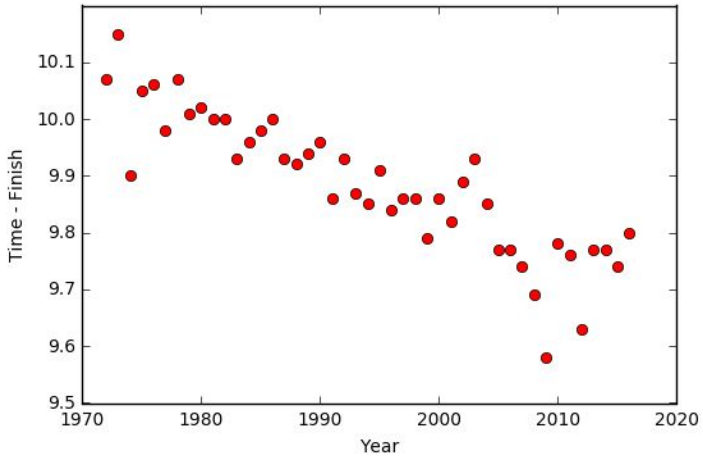
Simple Bar Graph

```
import re
import numpy as np
year = []
finish_time = []
with open("100m_running.csv", "r") as file:
    for line in file:
        line = re.sub("\s+", "", line)
        line_elements = line.split(",")
        if line_elements[0] != '':
            year.append(int(line_elements[0]))
        if line_elements[1] != '':
            finish_time.append(float(line_elements[1]))
# Here I have two lists. year & speed_time
import matplotlib.pyplot as plt
plt.bar(year, finish_time)
plt.xlabel("Year")
plt.ylabel("Time - Finish")
plt.show()
```



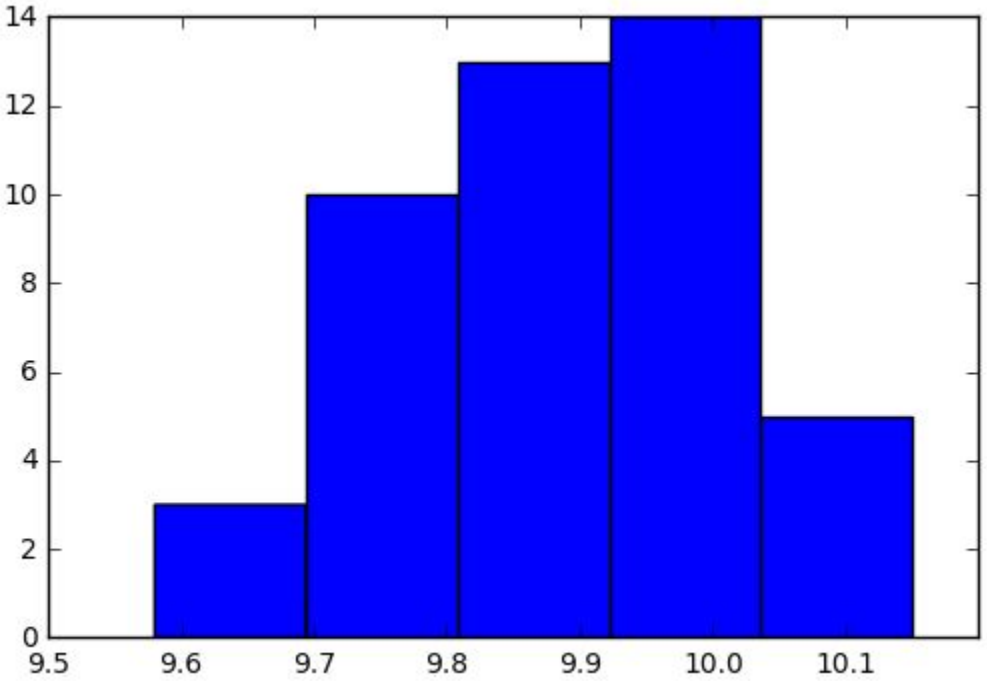
Simple Plot

```
import re
import numpy as np
year = []
finish_time = []
with open("100m_running.csv", "r") as file:
    for line in file:
        line = re.sub("\s+", "", line)
        line_elements = line.split(",")
        if line_elements[0] != '':
            year.append(int(line_elements[0]))
        if line_elements[1] != '':
            finish_time.append(float(line_elements[1]))
# Here I have two lists. year & speed_time
import matplotlib.pyplot as plt
plt.plot(year, finish_time, 'ro')
plt.xlabel("Year")
plt.ylabel("Time - Finish")
plt.show()
```



Histogram - Finish Time

```
plt.hist(finish_time, bins=5)
plt.show()
```

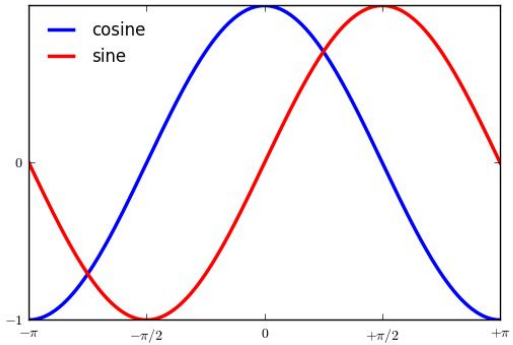


Customizing Graphs

```
import numpy as np
import matplotlib.pyplot as plt

X = np.linspace(-np.pi, np.pi, 256, endpoint=True)
C,S = np.cos(X), np.sin(X)
plt.xticks([-np.pi, -np.pi/2, 0, np.pi/2, np.pi],[r'$-\pi$', r'$-\pi/2$', r'$0$', r'$+\pi/2$', r'$+\pi$'])
plt.yticks([-1, 0, +1],[r'$-1$', r'$0$', r'$+1$'])
plt.plot(X, C, color="blue", linewidth=2.5, linestyle="-", label="cosine")
plt.plot(X, S, color="red",  linewidth=2.5, linestyle="-", label="sine")
plt.legend(loc='upper left', frameon=False)

plt.show()
```



Google Stock Price

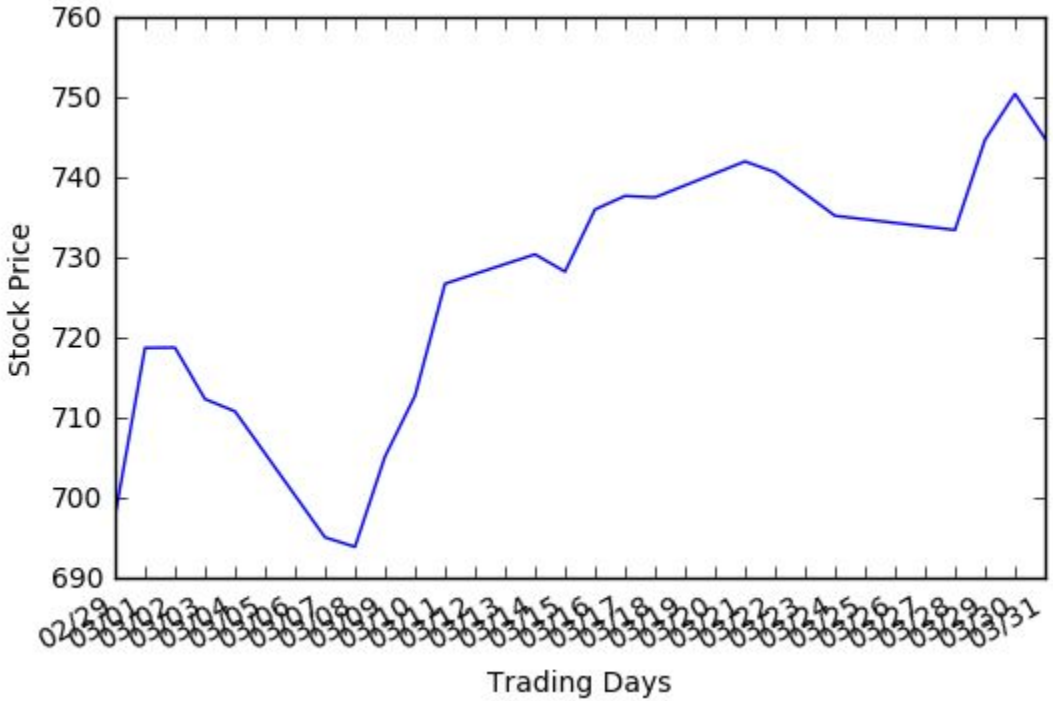
```
import datetime as dt
prices = []
dates = []
with open('GOOG.txt', "r") as f:
    for line in f:
        data = line.split(",")
        prices.append(data[1])
        day_y = data[0][0:4]
        day_m = data[0][4:6]
        day_d = data[0][6:8]
        dates.append(str(day_m) + '/' + str(day_d) + '/' + str(day_y))

days = [dt.datetime.strptime(d,'%m/%d/%Y').date() for d in dates]

import matplotlib.pyplot as plt
import matplotlib.dates as mdates

plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%m/%d'))
plt.gca().xaxis.set_major_locator(mdates.DayLocator())
plt.xlabel("Trading Days")
plt.ylabel("Stock Price")
plt.plot(days,prices)
plt.gcf().autofmt_xdate()
plt.show()
```

Google Stock Price (cont...)



Topics

- Hello Python
- Comments
- Mathematics
- Variables
- Data Types
- Making Decisions
- Strings
- Python Lists
- For, While - Loops
- Lists Revisits
- Handling Errors
- Functions
- Modules
- Packages
- Dictionaries
- Classes
- Iterators
- String Formatting
- **Regular Expressions**

Topics

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Pandas - Library for Data Analysis

Pandas Data Structures

- Series
- DataFrame

Both of them are built on the top of Numpy (... so are fast)

Series

- A Series is a one-dimensional object similar to an array, list, or column in a table.
- It will assign a labeled index to each item in the Series.
- By default, each item will receive an index label from 0 to N, where N is the length of the Series minus one.

```
>>> import pandas as pd
>>> s = pd.Series(['Usain Bolt', 9.63, 'Yohan Blake', 9.75, 'Justin Gatlin', 9.79])
>>> s
0       Usain Bolt
1             9.63
2      Yohan Blake
3             9.75
4    Justin Gatlin
5             9.79
dtype: object
>>>
```

Series (Cont...)

```
>>> s = pd.Series(['Usain Bolt', 9.63, 'Yohan Blake', 9.75, 'Justin Gatlin', 9.79], index=['A', 'B', 'C', 'D', 'E', 'F'])
>>> s
A       Usain Bolt
B             9.63
C      Yohan Blake
D             9.75
E    Justin Gatlin
F             9.79
dtype: object
>>>
```

You can also use Dictionary to create Series

```
>>> runners  =  {'Usain Bolt': 9.63, 'Yohan Blake': 9.75, 'Justin Gatlin': 9.79}
>>> runners
{'Yohan Blake': 9.75, 'Usain Bolt': 9.63, 'Justin Gatlin': 9.79}
>>> r = pd.Series(runners)
>>> r
Justin Gatlin    9.79
Usain Bolt       9.63
Yohan Blake      9.75
dtype: float64
>>>
```

Series (Cont...)

Accessing Elements are Easy

```
>>> r['Usain Bolt']
9.6300000000000008
>>> r['Yohan Blake']
9.75
>>>
```

```
>>> r[['Yohan Blake', 'Yohan Blake']]
Yohan Blake    9.75
Yohan Blake    9.75
dtype: float64
>>>
>>> r[['Yohan Blake', 'Usain Bolt']]
Yohan Blake    9.75
Usain Bolt     9.63
dtype: float64
>>>
```

```
>>> runners  =  {'Usain Bolt': 9.63, 'Yohan Blake': 9.75, 'Justin Gatlin': 9.79, 'Tyson Gay': 9.8, 'Ryan Bailey': 9.88, 'Churandy Martina': 9.94, 'Richard T
ompson': 9.98, 'Asafa Powell': 11.99}
>>>
>>> r = pd.Series(runners)
>>> r
Asafa Powell        11.99
Churandy Martina     9.94
Justin Gatlin        9.79
Richard Thompson     9.98
Ryan Bailey          9.88
Tyson Gay            9.80
Usain Bolt           9.63
Yohan Blake          9.75
dtype: float64
>>> r[r>10]
Asafa Powell    11.99
dtype: float64
>>> r[r<9.8]
Justin Gatlin    9.79
Usain Bolt       9.63
Yohan Blake      9.75
dtype: float64
>>>
```

Series (Cont...)

```
>>> r <9.8
Asafa Powell          False
Churandy Martina      False
Justin Gatlin          True
Richard Thompson      False
Ryan Bailey           False
Tyson Gay             False
Usain Bolt             True
Yohan Blake            True
dtype: bool
>>> my_requirement = r<9.8
>>> r[my_requirement]
Justin Gatlin    9.79
Usain Bolt       9.63
Yohan Blake      9.75
dtype: float64
>>>
```

Actually r<9.8 or r > 10
are series with True & False values.

Those can be passed to r - returning corresponding “True” value Series.

Series(Cont...)

One can change values on the fly

You can also check the presence of the value

```
>>> print ('Ironman' in r)
False
>>> print ('Superman' in r)
True
>>> print ('Milkha Singh' in r)
False
>>>
```

```
>>> r[['Superman']]
Superman   NaN
dtype: float64
>>> r['Superman']=5.0
>>> r['Batman'] = 6.0
>>> r
Asafa Powell         11.99
Churandy Martina      9.94
Justin Gatlin         9.79
Richard Thompson      9.98
Ryan Bailey           9.88
Tyson Gay             9.80
Usain Bolt            9.63
Yohan Blake           9.75
Superman              5.00
Batman                6.00
dtype: float64
>>> r[r<9] = 1.0
>>> r
Asafa Powell         11.99
Churandy Martina      9.94
Justin Gatlin         9.79
Richard Thompson      9.98
Ryan Bailey           9.88
Tyson Gay             9.80
Usain Bolt            9.63
Yohan Blake           9.75
Superman              1.00
Batman                1.00
dtype: float64
>>>
```

Series (Cont...)

Mathematics

```
>>> r * r
Asafa Powell          143.7601
Churandy Martina       98.8036
Justin Gatlin          95.8441
Richard Thompson       99.6004
Ryan Bailey            97.6144
Tyson Gay              96.0400
Usain Bolt             92.7369
Yohan Blake            95.0625
Superman                1.0000
Batman                  1.0000
dtype: float64
```

```
>>> r/2
Asafa Powell          5.995
Churandy Martina      4.970
Justin Gatlin         4.895
Richard Thompson      4.990
Ryan Bailey           4.940
Tyson Gay             4.900
Usain Bolt            4.815
Yohan Blake           4.875
Superman              0.500
Batman                0.500
dtype: float64
```

```
>>> r + r
Asafa Powell          23.98
Churandy Martina      19.88
Justin Gatlin         19.58
Richard Thompson      19.96
Ryan Bailey           19.76
Tyson Gay             19.60
Usain Bolt            19.26
Yohan Blake           19.50
Superman               2.00
Batman                 2.00
dtype: float64
```

```
>>> np.square(r)
Asafa Powell          143.7601
Churandy Martina       98.8036
Justin Gatlin          95.8441
Richard Thompson       99.6004
Ryan Bailey            97.6144
Tyson Gay              96.0400
```

Series (Cont...)

Mathematics

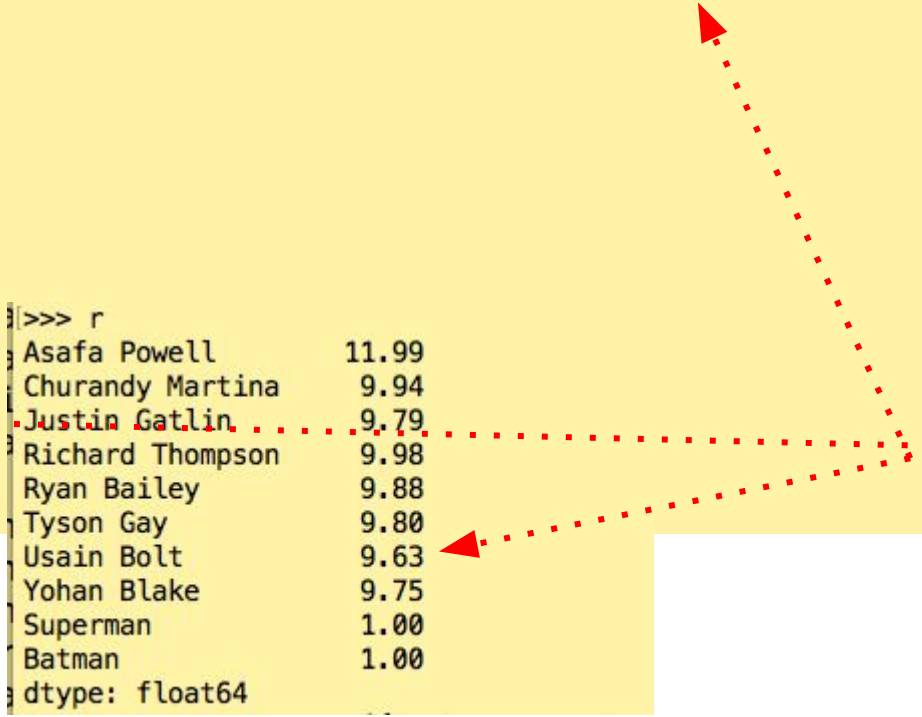
```
>>> new_r = pd.Series({'Lalita Baber': 15.0,  'O P Jaisha': 16.0, 'Kavita Raut': 20.0
>>> new_r
Kavita Raut     20.0
Lalita Baber    15.0
O P Jaisha      16.0
dtype: float64
```

```
>>> r + new_r
Asafa Powell       NaN
Batman             NaN
Churandy Martina   NaN
Justin Gatlin      NaN
Kavita Raut        NaN
Lalita Baber       NaN
O P Jaisha         NaN
Richard Thompson   NaN
Ryan Bailey        NaN
Superman           NaN
Tyson Gay          NaN
Usain Bolt         NaN
Yohan Blake        NaN
dtype: float64
```

Series (Cont...)

```
>>> new_r = pd.Series({'Lalita Baber': 15.0,  'O P Jaisha': 16.0, 'Kavita Raut': 20.0, 'Usain Bolt':9.63})
>>> r + new_r
Asafa Powell          NaN
Batman                NaN
Churandy Martina      NaN
Justin Gatlin         NaN
Kavita Raut           NaN
Lalita Baber          NaN
O P Jaisha            NaN
Richard Thompson      NaN
Ryan Bailey           NaN
Superman              NaN
Tyson Gay             NaN
Usain Bolt          19.26
Yohan Blake           NaN
dtype: float64
>>>
```

```
>>> r
Asafa Powell        11.99
Churandy Martina     9.94
Justin Gatlin        9.79
Richard Thompson     9.98
Ryan Bailey          9.88
Tyson Gay            9.80
Usain Bolt           9.63
Yohan Blake          9.75
Superman             1.00
Batman               1.00
dtype: float64
```



Series (Cont ...)

isnull & notnull instance methods

```
>>> new_r = pd.Series({'Lalita Baber': 15.0,  'O P Jaisha': 16.0, 'Kavita Raut': 20.0, 'Usain Bolt':9.63,  'Milkha Singh':None})
>>> new_r.isnull()
Kavita Raut     False
Lalita Baber    False
Milkha Singh     True
O P Jaisha      False
Usain Bolt      False
dtype: bool
>>> new_r.notnull()
Kavita Raut      True
Lalita Baber     True
Milkha Singh    False
O P Jaisha       True
Usain Bolt       True
dtype: bool
>>>
```

Series - Practice

- Use Fruits Data - create dictionary to work on Protein details. Use Fruits Names as Keys and values as Protien. Name dictionary as - “fruits”
- Create Series from “fruits” - call it “s_fruits”
- Perform
  - >, multiplication, np.square, addition, set values on the fly.
- Add “Onion” as key, with value= None, Recreate “s_fruits” Series
  - Observe “NaN” value
- Create new dictionary - “new_fruits” with keys “Raisins”, “Onion” (use same values of Protien as above)
- Perform “s_fruits” + “new_fruits”

DataFrame

"tabular" data: a data structure representing cases (rows), each of which consists of a number of observations or measurements (columns).

Player Name	Time	Height (Inches)	Weight (Pounds)	Country
Usain Bolt	9.63	76.77	209.439	JAM
Yohan Blake	9.75	70.86	167.551	JAM
Justin Gatlin	9.79	72.83	182.984	USA
Tyson Gay	9.8	70.07	165.347	USA
Ryan Bailey	9.88	75.98	216.053	USA
Churandy Martina	9.94	70.07	163.142	NED
Richard Thompson	9.98	70.01	176.37	TTO
Asafa Powell	11.99	70.8	191.802	JAM

DataFrame

```
>>> data = {'name':['Usain Bolt','Yohan Blake','Justin Gatlin','Tyson Gay','Ryan Bailey','Churandy Martina','Richard Thompson','Asafa Powell'],
...         'speed':[9.63,9.75,9.79,9.8,9.88,9.94,9.98,11.99],
...         'height':[76.77,70.86,72.83,70.07,75.98,70.07,70.01,70.8],
...         'weight':[209.439,167.551,182.984,165.347,216.053,163.142,176.37,191.802]}
>>>
```

```
>>> data
{'speed': [9.63, 9.75, 9.79, 9.8, 9.88, 9.94, 9.98, 11.99], 'name': ['Usain Bolt', 'Yohan Blake', 'Justin Gatlin', 'Tyson Gay', 'Ryan Bailey', 'Churandy Mart
ina', 'Richard Thompson', 'Asafa Powell'], 'height': [76.77, 70.86, 72.83, 70.07, 75.98, 70.07, 70.01, 70.8], 'weight': [209.439, 167.551, 182.984, 165.347,
216.053, 163.142, 176.37, 191.802]}
>>>
```

```
>>> runners = pd.DataFrame(data, columns=["name", "speed", "height", "weight"])
>>> runners
                name  speed  height   weight
0        Usain Bolt   9.63   76.77  209.439
1       Yohan Blake   9.75   70.86  167.551
2     Justin Gatlin   9.79   72.83  182.984
3         Tyson Gay   9.80   70.07  165.347
4       Ryan Bailey   9.88   75.98  216.053
5  Churandy Martina   9.94   70.07  163.142
6  Richard Thompson   9.98   70.01  176.370
7      Asafa Powell  11.99   70.80  191.802
>>>
```

DataFrame

```
>>> food = pd.read_csv("food.csv")
>>> food
                    Food  Index  Calories  Cholesterol  Total_Fat  Sodium  \
0          Frozen Broccoli      1      73.8          0.0        0.8    68.2
1              Carrots,Raw      2      23.7          0.0        0.1    19.2
2              Celery, Raw      3       6.4          0.0        0.1    34.8
3              Frozen Corn      4      72.2          0.0        0.6     2.5
4      Lettuce,Iceberg,Raw      5       2.6          0.0        0.0     1.8
5      Peppers, Sweet, Raw      6      20.0          0.0        0.1     1.5
6          Potatoes, Baked      7     171.5          0.0        0.2    15.2
7                     Tofu      8      88.2          0.0        5.5     8.1
8          Roasted Chicken      9     277.4        129.9       10.8   125.6
9        Spaghetti W/ Sauce     10     358.2          0.0       12.3  1237.1
10     Tomato,Red,Ripe,Raw     11      25.8          0.0        0.4    11.1
11        Apple,Raw,W/Skin     12      81.4          0.0        0.5     0.0
12                  Banana     13     104.9          0.0        0.5     1.1
13                  Grapes     14      15.1          0.0        0.1     0.5
14     Kiwifruit,Raw,Fresh     15      46.4          0.0        0.3     3.8
15                 Oranges     16      61.6          0.0        0.2     0.0
16                  Bagels     17      78.0          0.0        0.5   151.4
17            Wheat Bread     18      65.0          0.0        1.0   134.5
18            White Bread     19      65.0          0.0        1.0   132.5
19          Oatmeal Cookies     20      81.0          0.0        3.3    68.9
20                Apple Pie     21      67.2          0.0        2.1    75.4
```

DataFrame

```
>>> food.head()
                 Food  Index  Calories  Cholesterol  Total_Fat  Sodium  \
0      Frozen Broccoli      1      73.8          0.0        0.8    68.2
1          Carrots,Raw      2      23.7          0.0        0.1    19.2
2          Celery, Raw      3       6.4          0.0        0.1    34.8
3          Frozen Corn      4      72.2          0.0        0.6     2.5
4  Lettuce,Iceberg,Raw      5       2.6          0.0        0.0     1.8

   Carbohydrates  Dietary_Fiber  Protein    Vit_A  Vit_C  Calcium  Iron  \
0           13.6            8.5      8.0   5867.4  160.2    159.0   2.3
1            5.6            1.6      0.6  15471.0    5.1     14.9   0.3
2            1.5            0.7      0.3     53.6    2.8     16.0   0.2
3           17.1            2.0      2.5    106.6    5.2      3.3   0.3
4            0.4            0.3      0.2     66.0    0.8      3.8   0.1

   Price/Serving ($)
0               0.16
1               0.07
2               0.04
3               0.18
4               0.02
>>> food.tail(1)
                  Food  Index  Calories  Cholesterol  Total_Fat  Sodium  \
63  Beanbacn Soup,W/Watr     64     172.0          2.5        5.9   951.3

    Carbohydrates  Dietary_Fiber  Protein  Vit_A  Vit_C  Calcium  Iron  \
63           22.8            8.6      7.9  888.0    1.5     81.0   2.0

    Price/Serving ($)
63               0.67
>>> food.tail(3)
                  Food  Index  Calories  Cholesterol  Total_Fat  Sodium  \
61  New E Clamchwd,W/Mlk     62     163.7         22.3        6.6   992.0
62  Crm Mshrm Soup,W/Mlk     63     203.4         19.8       13.6  1076.3
```

- head()
- tail()
- info()
- describe()
- dtype
- columns

DataFrame

```
>>> food.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 64 entries, 0 to 63
Data columns (total 14 columns):
Food                64 non-null object
Index               64 non-null int64
Calories            64 non-null float64
Cholesterol         64 non-null float64
Total_Fat           64 non-null float64
Sodium              64 non-null float64
Carbohydrates       64 non-null float64
Dietary_Fiber       64 non-null float64
Protein             64 non-null float64
Vit_A               64 non-null float64
Vit_C               64 non-null float64
Calcium             64 non-null float64
Iron                64 non-null float64
Price/Serving ($)   64 non-null float64
dtypes: float64(12), int64(1), object(1)
memory usage: 7.1+ KB
>>>
```

```
>>> runners.describe()
            speed     height      weight
count    8.000000   8.000000    8.000000
mean    10.095000  72.173750  184.086000
std      0.773656   2.756555   20.171263
min      9.630000  70.010000  163.142000
25%      9.780000  70.070000  167.000000
50%      9.840000  70.830000  179.677000
75%      9.950000  73.617500  196.211250
max     11.990000  76.770000  216.053000
>>>
```

Databases - SQLite

```
root@6879840ae648:/datascience/sessions/data# sqlite3
SQLite version 3.11.0 2016-02-15 17:29:24
Enter ".help" for usage hints.
Connected to a transient in-memory database.
Use ".open FILENAME" to reopen on a persistent database.
sqlite>
sqlite>
sqlite>
sqlite> .help
.backup ?DB? FILE      Backup DB (default "main") to FILE
.bail on|off           Stop after hitting an error.  Default OFF
.binary on|off         Turn binary output on or off.  Default OFF
.changes on|off        Show number of rows changed by SQL
.clone NEWDB           Clone data into NEWDB from the existing database
.databases             List names and files of attached databases
.dbinfo ?DB?           Show status information about the database
.dump ?TABLE? ...      Dump the database in an SQL text format
                         If TABLE specified, only dump tables matching
                         LIKE pattern TABLE.
.echo on|off           Turn command echo on or off
.eqp on|off            Enable or disable automatic EXPLAIN QUERY PLAN
.exit                  Exit this program
.explain ?on|off|auto? Turn EXPLAIN output mode on or off or to automatic
```

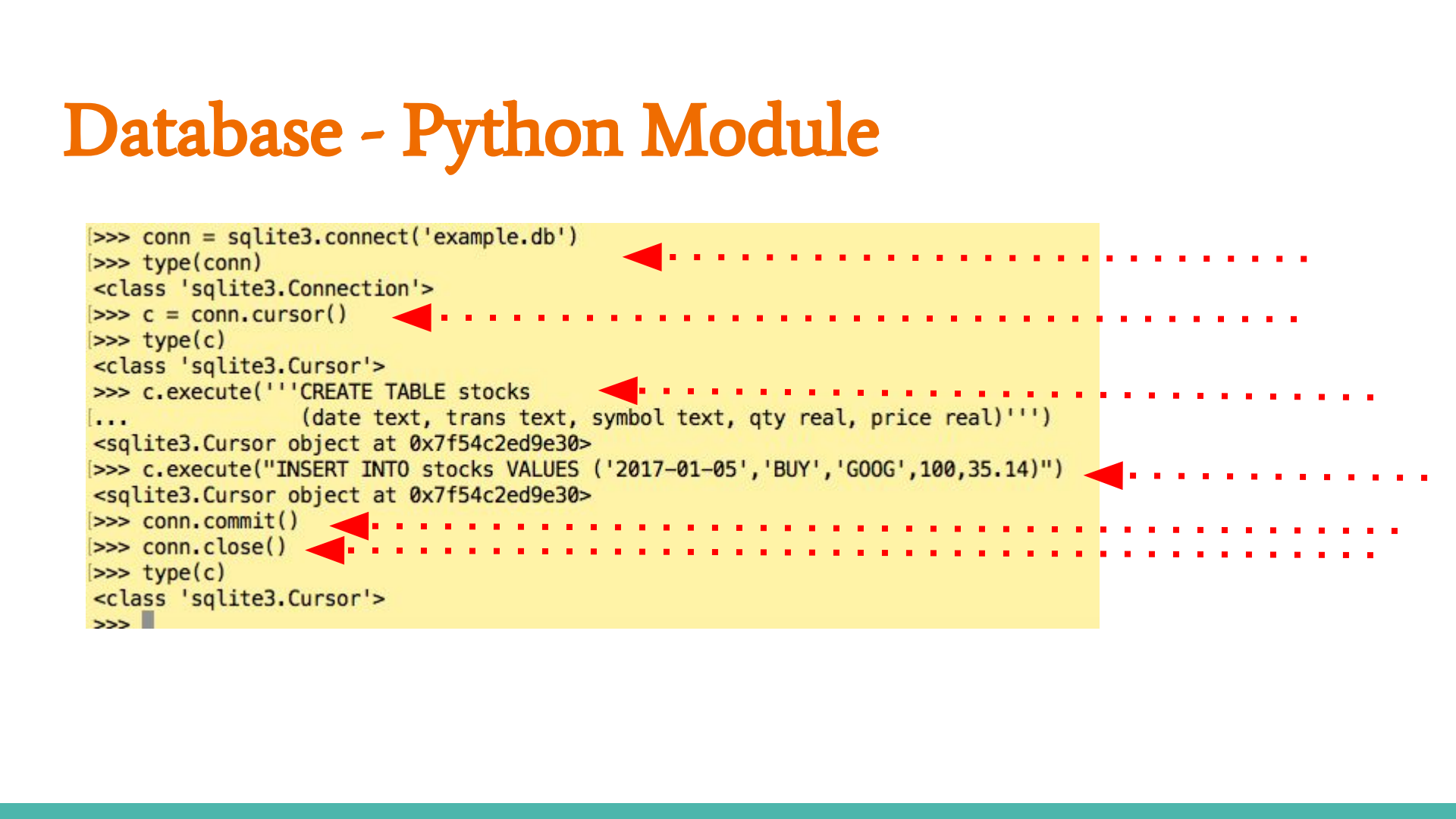
Databases - SQLite (Cont...)

```
sqlite> .schema
sqlite> CREATE TABLE presidents (
   ...> id int primary key NOT NULL,
   ...> name char(100) NOT NULL,
   ...> age  int NOT NULL);
sqlite> .schema
CREATE TABLE presidents (
id int primary key NOT NULL,
name char(100) NOT NULL,
age  int NOT NULL);
sqlite> select * from presidents;
sqlite> INSERT INTO presidents (id, name, age) VALUES(1, 'Donalt T', 74);
sqlite> select * from presidents;
1|Donalt T|74
sqlite> select name from presidents;
Donalt T
sqlite> INSERT INTO presidents (id, name, age) VALUES(2, 'Barack O', 54);
sqlite> select * from presidents;
1|Donalt T|74
2|Barack O|54
sqlite> select * from presidents where id=2;
2|Barack O|54
sqlite>
```

```
sqlite> select * from presidents ORDER BY age;
2|Barack O|54
1|Donalt T|74
sqlite>
```

Database - Python Module

```
>>> conn = sqlite3.connect('example.db')
>>> type(conn)
<class 'sqlite3.Connection'>
>>> c = conn.cursor()
>>> type(c)
<class 'sqlite3.Cursor'>
>>> c.execute('''CREATE TABLE stocks
...              (date text, trans text, symbol text, qty real, price real)''')
<sqlite3.Cursor object at 0x7f54c2ed9e30>
>>> c.execute("INSERT INTO stocks VALUES ('2017-01-05','BUY','GOOG',100,35.14)")
<sqlite3.Cursor object at 0x7f54c2ed9e30>
>>> conn.commit()
>>> conn.close()
>>> type(c)
<class 'sqlite3.Cursor'>
>>>
```



Database Python Module

```
root@6879840ae648:/datascience/sessions/data# python3
Python 3.5.2 (default, Nov 17 2016, 17:05:23)
[GCC 5.4.0 20160609] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import sqlite3
>>> conn = sqlite3.connect('example.db')
>>> c = conn.cursor()
>>> symbol = 'GOOG'
>>> c.execute("SELECT * FROM stocks WHERE symbol = '%s'" % symbol)
<sqlite3.Cursor object at 0x7f9d737f8e30>
>>> print(c.fetchone())
('2017-01-05', 'BUY', 'GOOG', 100.0, 35.14)
>>>
>>>
>>> t = ('GOOG',)
>>> c.execute('SELECT * FROM stocks WHERE symbol=?', t)
<sqlite3.Cursor object at 0x7f9d737f8e30>
>>> print(c.fetchone())
('2017-01-05', 'BUY', 'GOOG', 100.0, 35.14)
>>> purchases = [('2006-03-28', 'BUY', 'IBM', 1000, 45.00),
...              ('2006-04-05', 'BUY', 'MSFT', 1000, 72.00),
...              ('2006-04-06', 'SELL', 'IBM', 500, 53.00),
...             ]
>>>
>>> c.executemany('INSERT INTO stocks VALUES (?,?,?,?,?)', purchases)
<sqlite3.Cursor object at 0x7f9d737f8e30>
>>> for row in c.execute('SELECT * FROM stocks ORDER BY price'):
...     print(row)
...
('2017-01-05', 'BUY', 'GOOG', 100.0, 35.14)
('2006-03-28', 'BUY', 'IBM', 1000.0, 45.0)
('2006-04-06', 'SELL', 'IBM', 500.0, 53.0)
('2006-04-05', 'BUY', 'MSFT', 1000.0, 72.0)
>>>
```

create_db.py

```
#!/usr/bin/python3
import os
import sqlite3

db_filename = 'todo.db'
new_db = not os.path.exists(db_filename)

conn = sqlite3.connect(db_filename)

if new_db:
    print('Please create Schema')
else:
    print('Database already created - mostly schema exists')
conn.close()
```

Database - Project TODO

	project	
Column	**Type**	**Description**
name	text	Project Name
description	text	Project Description
deadline	date	Due Date

	task	
Column	**Type**	**Description**
id	number	Uniq Task Identifier
priority	integer	Priority of the task
details	text	Task Description
status	text	Status
deadline	date	Due Date
completed_on	date	Completion Date
project	text	Task Belongs to Project

Database - create schema & add data

```
#!/usr/bin/python3
import os
import sqlite3

db_filename = 'todo.db'
schema_filename = 'todo_schema.sql'

new_db = not os.path.exists(db_filename)

with sqlite3.connect(db_filename) as conn:
    if new_db:
        print('Let us create schema')
        with open(schema_filename, 'r') as f:
            schema = f.read()
        conn.executescript(schema)

        print('Inserting initial data')

        conn.executescript("""
        insert into project (name, description, deadline)
        values ('assignments', 'Assignments - Python for Data Science', '2017-05-24');

        insert into task (details, status, deadline, project)
        values ('assignment 1', 'done', '2017-01-29', 'assignments');

        insert into task (details, status, deadline, project)
        values ('assignment 2', 'in progress', '2017-02-22', 'assignments');

        insert into task (details, status, deadline, project)
        values ('assignment 3', 'active', '2017-03-31', 'assignments');
        """)
    else:
        print('Database exists, assume schema does, too.')
```

Database - Retrieve Data

```
#!/usr/bin/python3
import sqlite3

db_filename = 'todo.db'

with sqlite3.connect(db_filename) as conn:
    cursor = conn.cursor()

    cursor.execute(""" select id, priority, details, status, deadline from task where project = 'assignments' """)

    for row in cursor.fetchall():
        task_id, priority, details, status, deadline = row
        print('{:2d} [{:d}] {:<25} [{:<8}] ({})'.format( task_id, priority, details, status, deadline))
```

```
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [in progress] (2017-02-22)
 3 [1] assignment 3              [active  ] (2017-03-31)
```

Database - positional argument

```
#!/usr/bin/python3
import sqlite3
import sys

db_filename = 'todo.db'
project_name = sys.argv[1]

with sqlite3.connect(db_filename) as conn:
    cursor = conn.cursor()

    query = """ select id, priority, details, status, deadline from task where project = ?  """

    cursor.execute(query, (project_name,))

    for row in cursor.fetchall():
        task_id, priority, details, status, deadline = row
        print('{:2d} [{:d}] {:<25} [{:<8}] ({})'.format(task_id, priority, details, status, deadline))
```

```
root@6879840ae648:/datascience/sessions/ten# ./argument_positional.py assignments
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [in progress] (2017-02-22)
 3 [1] assignment 3              [active  ] (2017-03-31)
```

argument_named.py

```
#!/usr/bin/python3
import sqlite3
import sys

db_filename = 'todo.db'
project_name = sys.argv[1]

with sqlite3.connect(db_filename) as conn:
    cursor = conn.cursor()

    query = """ select id, priority, details, status, deadline from task where project = :project_name order by deadline, priority """

    cursor.execute(query, {'project_name': project_name})

    for row in cursor.fetchall():
        task_id, priority, details, status, deadline = row
        print('{:2d} [{:d}] {:<25} [{:<8}] ({})'.format(task_id, priority, details, status, deadline))
```

```
root@6879840ae648:/datascience/sessions/ten# ./argument_named.py assignments
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [in progress] (2017-02-22)
 3 [1] assignment 3              [active  ] (2017-03-31)
```

argument_update.py

```
#!/usr/bin/python3
import sqlite3
import sys

db_filename = 'todo.db'
project_name = sys.argv[1]

with sqlite3.connect(db_filename) as conn:
    cursor = conn.cursor()

    query = """ select id, priority, details, status, deadline from task where project = :project_name order by deadline, priority """

    cursor.execute(query, {'project_name': project_name})

    for row in cursor.fetchall():
        task_id, priority, details, status, deadline = row
        print('{:2d} [{:d}] {:<25} [{:<8}] ({})'.format(task_id, priority, details, status, deadline))
```

```
root@6879840ae648:/datascience/sessions/ten# ./argument_named.py assignments
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [in progress] (2017-02-22)
 3 [1] assignment 3              [active  ] (2017-03-31)
root@6879840ae648:/datascience/sessions/ten# ./argument_update.py 2 done
root@6879840ae648:/datascience/sessions/ten# ./argument_named.py assignments
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [done    ] (2017-02-22)
 3 [1] assignment 3              [active  ] (2017-03-31)
```

load_csv.py

```
#!/usr/bin/python3
import csv
import sqlite3
import sys

db_filename = 'todo.db'
data_filename = sys.argv[1]

SQL = """ insert into task (details, priority, status, deadline, project) values (:details, :priority, 'active', :deadline, :project) """

with open(data_filename, 'r') as csv_file:
    csv_reader = csv.DictReader(csv_file)
    with sqlite3.connect(db_filename) as conn:
        cursor = conn.cursor()
        cursor.executemany(SQL, csv_reader)
```

```
root@6879840ae648:/datascience/sessions/ten# more tasks.csv
deadline,project,priority,details
2017-03-01,assignments,2,"Submission of all assignments"
2017-03-08,assignments,3,"Work on Project"
2017-03-16,assignments,1,"Finish Documentation"
```

```
root@6879840ae648:/datascience/sessions/ten# ./load_csv.py tasks.csv
root@6879840ae648:/datascience/sessions/ten# ./argument_named.py assignments
 1 [1] assignment 1              [done    ] (2017-01-29)
 2 [1] assignment 2              [done    ] (2017-02-22)
 4 [2] Submission of all assignments [active  ] (2017-03-01)
 5 [3] Work on Project           [active  ] (2017-03-08)
 6 [1] Finish Documentation      [active  ] (2017-03-16)
 3 [1] assignment 3              [active  ] (2017-03-31)
```

Back to Pandas

datetime Library

```
root@6879840ae648:/datascience/sessions/eleven# more 1.py
#!/usr/bin/python3
from datetime import datetime

now = datetime.now()
print('The dateformat: {}'.format(now))
print ('The year is = {}'.format(now.year))
print ('The month is = {}'.format(now.month))
print ('The day is = {} '.format(now.day))

#           datetime(year, month, day[, hour[, minute[, second[, microsecond[,tzinfo]]]]])
#                       Y  M  d   h  m    s      ms
that_day = datetime(2017, 3, 1, 17, 9,  21, 832092)
print('The dateformat: {}'.format(that_day))
print ('The year is = {}'.format(that_day.year))
print ('The month is = {}'.format( that_day.month))
print ('The day is = {} '.format(that_day.day))

root@6879840ae648:/datascience/sessions/eleven# ./1.py
The dateformat: 2017-03-31 14:52:04.730385
The year is = 2017
The month is = 3
The day is = 31
The dateformat: 2017-03-01 17:09:21.832092
The year is = 2017
The month is = 3
The day is = 1
root@6879840ae648:/datascience/sessions/eleven#
```

Difference - datetime

```
root@6879840ae648:/datascience/sessions/eleven# more delta.py
#!/usr/bin/python3
from datetime import datetime
#           datetime(year, month, day[, hour[, minute[, second[, microsecond[,tzinfo]]]]])
#                    Y  M   d   h   m  s      ms                  Y  M  d   h   m  s      ms
delta = datetime(2017, 3, 25, 18, 21, 1, 123000) - datetime (2016, 1, 1, 18, 51, 51, 123000)
print(delta)
print (delta.days)
print (delta.seconds)



root@6879840ae648:/datascience/sessions/eleven# ./delta.py
448 days, 23:29:10
448
84550
```

timedelta

```
root@6879840ae648:/datascience/sessions/eleven# more timedelta.py
#!/usr/bin/python3
from datetime import datetime, timedelta

start = datetime(2017, 4, 1)
print (start)


new_s = start + timedelta (12)
print (new_s)

prev_s = start - 2 * timedelta(12)

print (prev_s)


root@6879840ae648:/datascience/sessions/eleven# ./timedelta.py
2017-04-01 00:00:00
2017-04-13 00:00:00
2017-03-08 00:00:00
```

strings and datetime

```
root@6879840ae648:/datascience/sessions/eleven# more str_1.py
#!/usr/bin/python3
from datetime import datetime

d_stamp = datetime(2017, 3, 31)
print(d_stamp)
print (str(d_stamp))
print ("----------------------\n")

# Use of strftime  - datetime to string
print (d_stamp.strftime('%Y/%m/%d'))
print (d_stamp.strftime('%Y-%m-%d'))
print (d_stamp.strftime('%Y, %d %m'))
print ("----------------------\n")


# Use of strptime - strings to datetime
d = '2017-03-31'

print (datetime.strptime(d, '%Y-%m-%d'))
print ("----------------------\n")

datestrs = ['01/Jan/2017', '01/Feb/2017', '01/Mar/2017', '01/Apr/2017']
print ([datetime.strptime(x, '%d/%b/%Y') for x in datestrs])
print ("----------------------\n")
```

strings and datetime (cont...)

```
root@6879840ae648:/datascience/sessions/eleven# ./str_1.py
2017-03-31 00:00:00
2017-03-31 00:00:00
--------------------

2017/03/31
2017-03-31
2017, 31 03
--------------------

2017-03-31 00:00:00
--------------------

[datetime.datetime(2017, 1, 1, 0, 0), datetime.datetime(2017, 2, 1, 0, 0), datetime.datetime(2017, 3, 1, 0, 0), datetime.datetime(2017, 4, 1, 0, 0)]
--------------------
```

dateutil

```
root@6879840ae648:/datascience/sessions/eleven# more pars_util.py
#!/usr/bin/python3
from dateutil.parser import parse

d1 = parse('2017-01-25')
print (type(d1))
print (d1)
print ("-------------\n")

d2 = parse('Jan 01, 2017 10:30 AM')
print (type(d2))
print (d2)
print ("-------------\n")

d3 = parse('01/01/2017', dayfirst=True)
print (type(d3))
print (d3)
print ("-------------\n")

root@6879840ae648:/datascience/sessions/eleven# ./pars_util.py
<class 'datetime.datetime'>
2017-01-25 00:00:00
-------------

<class 'datetime.datetime'>
2017-01-01 10:30:00
-------------

<class 'datetime.datetime'>
2017-01-01 00:00:00
```

pandas & datetime

```
root@6879840ae648:/datascience/sessions/eleven# python3
Python 3.5.2 (default, Nov 17 2016, 17:05:23)
[GCC 5.4.0 20160609] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import pandas as pd
>>> datestrs = ['01/01/2017', '02/01/2017']
>>> pd.to_datetime(datestrs)
DatetimeIndex(['2017-01-01', '2017-02-01'], dtype='datetime64[ns]', freq=None)
>>> idx = pd.to_datetime(datestrs + [None, ''])
>>> idx
DatetimeIndex(['2017-01-01', '2017-02-01', 'NaT', 'NaT'], dtype='datetime64[ns]', freq=None)
>>> idx[2]
NaT
>>> idx[3]
NaT
>>> pd.isnull(idx)
array([False, False,  True,  True], dtype=bool)
>>>
```

Series

```
root@6879840ae648:/datascience/sessions/eleven# more time_basics_pandas.py
#!/usr/bin/python3
import pandas as pd
import numpy as np

from pandas import Series, DataFrame
from datetime import datetime

dates = [
          datetime(2017, 1, 1),
          datetime(2017, 1, 2),
          datetime(2017, 1, 3),
          datetime(2017, 1, 4),
          datetime(2017, 1, 5),
        ]

ts =  Series(np.random.randn(5), index=dates)
print(type(ts))
print(ts)
print ("------------\n")

print(type(ts.index))
print(ts.index)
print ("------------\n")

print (ts.index[0])
print (type(ts.index[0]))
print (ts.index.dtype)
print ("------------\n")
```

Series (Cont...)

```
root@6879840ae648:/datascience/sessions/eleven# ./time_basics_pandas.py
<class 'pandas.core.series.Series'>
2017-01-01    0.949770
2017-01-02   -0.165319
2017-01-03   -1.112256
2017-01-04   -0.393262
2017-01-05   -0.828009
dtype: float64
------------

<class 'pandas.tseries.index.DatetimeIndex'>
DatetimeIndex(['2017-01-01', '2017-01-02', '2017-01-03', '2017-01-04',
               '2017-01-05'],
              dtype='datetime64[ns]', freq=None)
------------

2017-01-01 00:00:00
<class 'pandas.tslib.Timestamp'>
datetime64[ns]
------------
```

Handling Missing Values

Data Sets Missing - Why?

So many Reasons -

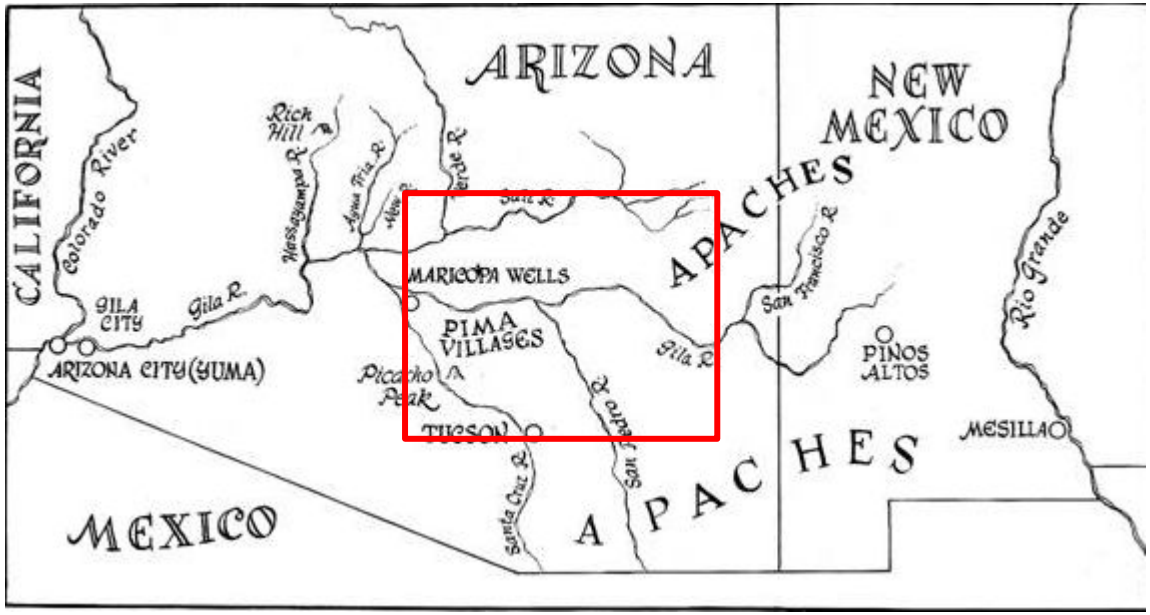
- Data could not get recorded - Manual, Automation (both can fail - its magical)
- Data got corrupted - world is not perfect

What do we do then?

- We need to handle it sensibly - off course, knowledge about data plays important Role

Example - Pima Indians Diabetes Dataset

- Info on Pima Indians - https://en.wikipedia.org/wiki/Pima_people
- Data Source - https://archive.ics.uci.edu/ml/datasets/Pima+Indians+Diabetes



Pima Indians Diabetes Dataset (Cont...)

The number of observations for each class is not balanced. There are 768 observations with 8 input variables. The variable names are as follows:

0	Number of times pregnant.
1	Plasma glucose concentration a 2 hours in an oral glucose tolerance test.
2	Diastolic blood pressure (mm Hg).
3	Triceps skinfold thickness (mm).
4	2-Hour serum insulin (mu U/ml).
5	Body mass index (weight in kg/(height in m)^2).
6	Diabetes pedigree function.
7	Age (years).
8	Class variable (0 or 1).

Pima Indians Diabetes Dataset (Cont...)

Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
6	148	72	35	0	33.6	0.627	50	1
1	85	66	29	0	26.6	0.351	31	0
8	183	64	0	0	23.3	0.672	32	1
1	89	66	23	94	28.1	0.167	21	0
0	137	40	35	168	43.1	2.288	33	1
5	116	74	0	0	25.6	0.201	30	0
3	78	50	32	88	31	0.248	26	1
10	115	0	0	0	35.3	0.134	29	0
2	197	70	45	543	30.5	0.158	53	1

zero for body mass index or blood pressure is invalid.

Pima Indians Diabetes Dataset (Cont...)

You can not have “Zero” to a few columns

1, 2, 3, 4, 5

1	Plasma glucose concentration a 2 hours in an oral glucose tolerance test.
2	Diastolic blood pressure (mm Hg).
3	Triceps skinfold thickness (mm).
4	2-Hour serum insulin (mu U/ml).
5	Body mass index (weight in kg/(height in m)^2).

In [15]:
```
import pandas as pd
dataset = pd.read_csv('pima_diab.csv', header=None)
dataset.describe()
```

Zero is affecting here

Out[15]:

	0	1	2	3	4	5	6	7	8
count	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000
mean	3.845052	120.894531	69.105469	20.536458	79.799479	31.992578	0.471876	33.240885	0.348958
std	3.369578	31.972618	19.355807	15.952218	115.244002	7.884160	0.331329	11.760232	0.476951
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.078000	21.000000	0.000000
25%	1.000000	99.000000	62.000000	0.000000	0.000000	27.300000	0.243750	24.000000	0.000000
50%	3.000000	117.000000	72.000000	23.000000	30.500000	32.000000	0.372500	29.000000	0.000000
75%	6.000000	140.250000	80.000000	32.000000	127.250000	36.600000	0.626250	41.000000	1.000000
max	17.000000	199.000000	122.000000	99.000000	846.000000	67.100000	2.420000	81.000000	1.000000

The columns

2, 3, 4, 5 - clearly has

“0” as values.

That’s confirmation :)

```
In [9]: dataset.head(20)
```

Out[9]:

	0	1	2	3	4	5	6	7	8
0	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
1	6	148	72	35	0	33.6	0.627	50	1
2	1	85	66	29	0	26.6	0.351	31	0
3	8	183	64	0	0	23.3	0.672	32	1
4	1	89	66	23	94	28.1	0.167	21	0
5	0	137	40	35	168	43.1	2.288	33	1
6	5	116	74	0	0	25.6	0.201	30	0
7	3	78	50	32	88	31	0.248	26	1
8	10	115	0	0	0	35.3	0.134	29	0
9	2	197	70	45	543	30.5	0.158	53	1
10	8	125	96	0	0	0	0.232	54	1
11	4	110	92	0	0	37.6	0.191	30	0
12	10	168	74	0	0	38	0.537	34	1
13	10	139	80	0	0	27.1	1.441	57	0
14	1	189	60	23	846	30.1	0.398	59	1
15	5	166	72	19	175	25.8	0.587	51	1
16	7	100	0	0	0	30	0.484	32	1
17	0	118	84	47	230	45.8	0.551	31	1
18	7	107	74	0	0	29.6	0.254	31	1
19	1	103	30	38	83	43.3	0.183	33	0

How many invalid records?

```
In [16]: print((dataset[[1,2,3,4,5]] == 0).sum())
1      5
2     35
3    227
4    374
5     11
dtype: int64
```

Replace invalid with meaningful values

```
In [18]: import numpy as np
         dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, np.NaN)

In [19]: dataset
```

Out[19]:

	0	1	2	3	4	5	6	7	8
0	6	148.0	72.0	35.0	NaN	33.6	0.627	50	1
1	1	85.0	66.0	29.0	NaN	26.6	0.351	31	0
2	8	183.0	64.0	NaN	NaN	23.3	0.672	32	1
3	1	89.0	66.0	23.0	94.0	28.1	0.167	21	0
4	0	137.0	40.0	35.0	168.0	43.1	2.288	33	1
5	5	116.0	74.0	NaN	NaN	25.6	0.201	30	0
6	3	78.0	50.0	32.0	88.0	31.0	0.248	26	1
7	10	115.0	NaN	NaN	NaN	35.3	0.134	29	0
8	2	197.0	70.0	45.0	543.0	30.5	0.158	53	1
9	8	125.0	96.0	NaN	NaN	NaN	0.232	54	1
10	4	110.0	92.0	NaN	NaN	37.6	0.191	30	0
11	10	168.0	74.0	NaN	NaN	38.0	0.537	34	1
12	10	139.0	80.0	NaN	NaN	27.1	1.441	57	0

Let us mark them with "NaN" using pandas "replace" method

```
In [20]: print(dataset.isnull().sum())

0      0
1      5
2     35
3    227
4    374
5     11
6      0
7      0
8      0
dtype: int64
```

Missing Values are trouble

Missing Values can be troublesome to some of the Machine Learning Algorithms

Let us evaluate Linear Discriminant Analysis (LDA) here.

Missing Values are trouble (Cont...)

In [13]:

```
from pandas import read_csv
import numpy
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score

dataset = read_csv('pima_diab.csv', header=None)
# mark zero values as missing or NaN
dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, numpy.NaN)

# split dataset into inputs and outputs
values = dataset.values
X = values[:,0:8]
y = values[:,8]

# evaluate an LDA model on the dataset using k-fold cross validation
model = LinearDiscriminantAnalysis()
kfold = KFold(n_splits=3, random_state=7)
result = cross_val_score(model, X, y, cv=kfold, scoring='accuracy')

print(result.mean())
```

Missing Values are trouble (Cont...)

We are prevented from evaluating an LDA algorithm (and other algorithms) on the dataset with missing values.

```
    522     if multi_output:
    523         y = check_array(y, 'csr', force_all_finite=True, ensure_2d=False,

/usr/local/lib/python3.5/dist-packages/sklearn/utils/validation.py in check_array(array, accept_sparse, dtype, order,
 copy, force_all_finite, ensure_2d, allow_nd, ensure_min_samples, ensure_min_features, warn_on_dtype, estimator)
    405                                       % (array.ndim, estimator_name))
    406         if force_all_finite:
--> 407             _assert_all_finite(array)
    408
    409     shape_repr = _shape_repr(array.shape)

/usr/local/lib/python3.5/dist-packages/sklearn/utils/validation.py in _assert_all_finite(X)
     56             and not np.isfinite(X).all()):
     57         raise ValueError("Input contains NaN, infinity"
---> 58                          " or a value too large for %r." % X.dtype)
     59
     60

ValueError: Input contains NaN, infinity or a value too large for dtype('float64').
```

Drop the Rows with Missing Values

Pandas provides the “dropna()” function that can be used to drop either columns or rows with missing data

In [14]:
```
from pandas import read_csv
import numpy
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score

dataset = read_csv('pima_diab.csv', header=None)
# mark zero values as missing or NaN
dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, numpy.NaN)

# drop rows with missing values
dataset.dropna(inplace=True)
# summarize the number of rows and columns in the dataset
print(dataset.shape)
```

```
(392, 9)
```

Finally

In [15]:

```
from pandas import read_csv
import numpy
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score

dataset = read_csv('pima_diab.csv', header=None)
# mark zero values as missing or NaN
dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, numpy.NaN)

# drop rows with missing values
dataset.dropna(inplace=True)
# summarize the number of rows and columns in the dataset
print(dataset.shape)

# split dataset into inputs and outputs
values = dataset.values
X = values[:,0:8]
y = values[:,8]

# evaluate an LDA model on the dataset using k-fold cross validation
model = LinearDiscriminantAnalysis()
kfold = KFold(n_splits=3, random_state=7)
result = cross_val_score(model, X, y, cv=kfold, scoring='accuracy')
print(result.mean())
```

```
(392, 9)
0.78582892934
```

Impute those Values

Removing rows with missing values can be too limiting on some predictive modeling problems, an alternative is to impute missing values.

A few Options to replace a missing value

- A constant value that has meaning within the domain, such as 0, distinct from all other values.
- A value from another randomly selected record.
- A mean, median or mode value for the column.
- A value estimated by another predictive model.

So new Data Derived - and new models applied on the data

Let us go with mean column values.

These mean column values will need to be stored to file for later use.

Pandas provides the “fillna()” function for replacing missing values with a specific value.

Replace with Mean

In [16]:
```
from pandas import read_csv
import numpy
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score

dataset = read_csv('pima_diab.csv', header=None)
# mark zero values as missing or NaN
dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, numpy.NaN)

# fill missing values with mean column values
dataset.fillna(dataset.mean(), inplace=True)
# count the number of NaN values in each column
print(dataset.isnull().sum())
```

```
0    0
1    0
2    0
3    0
4    0
5    0
6    0
7    0
8    0
dtype: int64
```

Finally

In [17]:

```
from pandas import read_csv
import numpy
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score

dataset = read_csv('pima_diab.csv', header=None)
# mark zero values as missing or NaN
dataset[[1,2,3,4,5]] = dataset[[1,2,3,4,5]].replace(0, numpy.NaN)

# fill missing values with mean column values
dataset.fillna(dataset.mean(), inplace=True)
# count the number of NaN values in each column
#print(dataset.isnull().sum())

values = dataset.values
X = values[:,0:8]
y = values[:,8]
# evaluate an LDA model on the dataset using k-fold cross validation
model = LinearDiscriminantAnalysis()
kfold = KFold(n_splits=3, random_state=7)
result = cross_val_score(model, X, y, cv=kfold, scoring='accuracy')
print(result.mean())
```

```
0.766927083333
```

```
>>> import pandas as pd
>>> raw_data = {
...             'subject': ['1', '2', '3', '4', '5'],
...             'first_name': ['Michel', 'Mark', 'Matt', 'Ryan', 'Gary'],
...             'last_name': ['Phelps', 'Spitz', 'Biondi', 'Lochte', 'Hall']
...           }
>>>
>>> raw_data
{'subject': ['1', '2', '3', '4', '5'], 'first_name': ['Michel', 'Mark', 'Matt', 'Ryan', 'Gary'], 'last_name': ['Phelps', 'Spitz', 'Biondi', 'Lochte', 'Hall'
]}
>>> df_a = pd.DataFrame(raw_data, columns = ['subject', 'first_name', 'last_name'])
>>> df_a
  subject first_name last_name
0       1     Michel    Phelps
1       2       Mark     Spitz
2       3       Matt    Biondi
3       4       Ryan    Lochte
4       5       Gary      Hall
>>>
```

```
>>> raw_data = {
...             'subject': ['4', '5', '6', '7', '8', '9'],
...             'first_name': ['Ian', 'Aaron', 'Nathan', 'Tom', 'Don', 'Johny'],
...             'last_name': ['Thorpe', 'Peirsol', 'Adrian', 'Jager', 'Schollander', 'Weis']
...            }
>>> df_b = pd.DataFrame(raw_data, columns = ['subject', 'first_name', 'last_name'])
>>> df_b
  subject first_name    last_name
0       4        Ian       Thorpe
1       5      Aaron      Peirsol
2       6     Nathan       Adrian
3       7        Tom        Jager
4       8        Don  Schollander
5       9      Johny         Weis
>>>
```

```
>>> raw_data = {
...             'subject': ['1', '2', '3', '4', '5', '7', '8', '9', '10', '11'],
...             'test'   : [51, 15, 15, 61, 16, 14, 15, 1, 61, 16]
...            }
>>> df_n = pd.DataFrame(raw_data, columns = ['subject','test'])
>>> df_n
  subject  test
0       1    51
1       2    15
2       3    15
3       4    61
4       5    16
5       7    14
6       8    15
7       9     1
8      10    61
9      11    16
>>>
>>>
```

Join Two DataFrames - along rows

```
>>> df_new = pd.concat([df_a, df_b])
>>> df_new
  subject first_name    last_name
0       1     Michel       Phelps
1       2       Mark        Spitz
2       3       Matt       Biondi
3       4       Ryan       Lochte
4       5       Gary         Hall
0       4        Ian       Thorpe
1       5      Aaron      Peirsol
2       6     Nathan       Adrian
3       7        Tom        Jager
4       8        Don  Schollander
5       9      Johny         Weis
>>>
```

Join Two DataFrames - along rows

```
>>> df_new = pd.concat([df_a, df_b])
>>> df_new
  subject first_name    last_name
0       1     Michel       Phelps
1       2       Mark        Spitz
2       3       Matt       Biondi
3       4       Ryan       Lochte
4       5       Gary         Hall
0       4        Ian       Thorpe
1       5      Aaron      Peirsol
2       6     Nathan       Adrian
3       7        Tom        Jager
4       8        Don  Schollander
5       9      Johny         Weis
>>>
```

Join Two Dataframes - along axis

```
>>>
>>> pd.concat([df_a, df_b], axis=1)
  subject first_name last_name subject first_name    last_name
0       1     Michel    Phelps       4        Ian       Thorpe
1       2       Mark     Spitz       5      Aaron      Peirsol
2       3       Matt    Biondi       6     Nathan       Adrian
3       4       Ryan    Lochte       7        Tom        Jager
4       5       Gary      Hall       8        Don  Schollander
5     NaN        NaN       NaN       9      Johny         Weis
>>>
```

Merge Two DataFrames - along one column

```
>>> pd.merge(df_new, df_n, on='subject')
   subject first_name    last_name  test
0        1     Michel       Phelps    51
1        2       Mark        Spitz    15
2        3       Matt       Biondi    15
3        4       Ryan       Lochte    61
4        4        Ian       Thorpe    61
5        5       Gary         Hall    16
6        5      Aaron      Peirsol    16
7        7        Tom        Jager    14
8        8        Don  Schollander    15
9        9      Johny         Weis     1
>>>
```

Merge dataframes with both the left and right dataframes using the one key

```
>>> pd.merge(df_new, df_n, left_on='subject', right_on='subject')
   subject first_name    last_name  test
0        1     Michel       Phelps    51
1        2       Mark        Spitz    15
2        3       Matt       Biondi    15
3        4       Ryan       Lochte    61
4        4        Ian       Thorpe    61
5        5       Gary         Hall    16
6        5      Aaron      Peirsol    16
7        7        Tom        Jager    14
8        8        Don  Schollander    15
9        9      Johny         Weis     1
>>>
```

Merge with outer join

```
>>> pd.merge(df_a, df_b, on='subject', how='outer')
   subject first_name_x last_name_x first_name_y  last_name_y
0        1       Michel      Phelps          NaN          NaN
1        2         Mark       Spitz          NaN          NaN
2        3         Matt      Biondi          NaN          NaN
3        4         Ryan      Lochte          Ian       Thorpe
4        5         Gary        Hall       Aaron      Peirsol
5        6          NaN         NaN      Nathan       Adrian
6        7          NaN         NaN         Tom        Jager
7        8          NaN         NaN         Don  Schollander
8        9          NaN         NaN       Johny         Weis
>>>
```

Merge with Inner Join

```
>>> pd.merge(df_a, df_b, on='subject', how='inner')
   subject first_name_x last_name_x first_name_y last_name_y
0        4         Ryan      Lochte          Ian      Thorpe
1        5         Gary        Hall        Aaron     Peirsol
>>>
```

Left and Right Join

```
>>> pd.merge(df_a, df_b, on='subject', how='right')
   subject first_name_x last_name_x first_name_y  last_name_y
0        4         Ryan      Lochte          Ian       Thorpe
1        5         Gary        Hall        Aaron      Peirsol
2        6          NaN         NaN       Nathan       Adrian
3        7          NaN         NaN          Tom        Jager
4        8          NaN         NaN          Don  Schollander
5        9          NaN         NaN        Johny         Weis
>>> pd.merge(df_a, df_b, on='subject', how='left')
   subject first_name_x last_name_x first_name_y last_name_y
0        1       Michel      Phelps          NaN         NaN
1        2         Mark       Spitz          NaN         NaN
2        3         Matt      Biondi          NaN         NaN
3        4         Ryan      Lochte          Ian      Thorpe
4        5         Gary        Hall        Aaron     Peirsol
>>>
>>>
```

Add Suffixes

```
>>> pd.merge(df_a, df_b, on='subject', how='left', suffixes=('_left', '_right'))
  subject first_name_left last_name_left first_name_right last_name_right
0       1          Michel         Phelps              NaN             NaN
1       2            Mark          Spitz              NaN             NaN
2       3            Matt         Biondi              NaN             NaN
3       4            Ryan         Lochte              Ian          Thorpe
4       5            Gary           Hall           Aaron         Peirsol
>>>
```

Thank you!