Python Fundamentals

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Agenda

- Python Basics
- Functions
- Control flow
- Shell & Magic commands
- Handling Files
- Scalar types (Numeric, String, Boolean, None)
- Data structures (Tuple, List)
- Comprehensions
- Annex: Python notebook

How to start python?

- The standard interactive Python interpreter: python
- To exit the Python interpreter: exit() or press Ctrl-D.
- Running Python programs: python followed by .py file as its first argument.

```
dsc: ~ 130 % python
Python 3.6.2 |Anaconda custom (64-bit)| (default, Sep 30 2017, 18:42:57)
[GCC 7.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> a=5
>>> print(a)
5
>>> print(a*2)
10
>>>
dsc: ~ % echo "print('Hello world from python')">hello_world.py
dsc: ~ % python ./hello_world.py
Hello world from python
dsc: ~ %
```

How to start python?

- ipython an **enhanced** interactive Python interpreter.
- Fernando Pérez, a physics grad student https://www.youtube.com/watch?v=g8xQRI3E8r8
- ~~command history + auto completion +~~ **interactivity**
- Interactivity with **%run** command

```
dsc: ~ % ipython
Python 3.6.2 |Anaconda custom (64-bit)| (default, Sep 30 2017, 18:42:57)
Type 'copyright', 'credits' or 'license' for more information
IPython 6.1.0 -- An enhanced Interactive Python. Type '?' for help.

In [1]: %run ./hello_world.py
Hello world from python

In [2]:
```

Jupyter Notebook

- Jupyter Notebook
- interactive computational environment, in which you can combine code execution, rich text, mathematics, plots and rich media.

- Go out of iPython, type **jupyter-notebook** in your terminal

Jupyther notebook

- Jupyther notebook app is a server that appears in your browser at a default address (*http://localhost:8888*).
- Closing the browser will not shut down the server.
- You can reopen the previous address and the Jupyther notebook app will be redisplayed.

- When a notebook is opened, its “computational engine” (called the kernel) is automatically started.
- Closing the notebook browser tab, will not shut down the kernel, instead the kernel will keep running until is explicitly shut down.

Jupyther notebook

- You can run the notebook document step-by-step (one cell a time) by pressing **shift + enter**.
- You can run the whole notebook in a single step by clicking on the menu Cell -> **Run All**.
- To **restart the kernel** (i.e. the computational engine), click on the menu Kernel -> Restart. This can be useful to start over a computation from scratch (e.g. variables are deleted, open files are closed, etc...).
- **Shift+tab**=help over the command

Command Mode (press Esc to enable)

F: find and replace
Ctrl-Shift-P: open the command palette
Enter: enter edit mode
Shift-Enter: run cell, select below
Ctrl-Enter: run selected cells
Alt-Enter: run cell, insert below
Y: to code
M: to markdown
R: to raw
1: to heading 1
2: to heading 2
3: to heading 3
4: to heading 4
5: to heading 5
6: to heading 6
K: select cell above
Up: select cell above
Down: select cell below
J: select cell below
Shift-K: extend selected cells above
Shift-Up: extend selected cells above
Shift-Down: extend selected cells below
Shift-J: extend selected cells below
A: insert cell above
B: insert cell below
X: cut cell
C: copy cell
Shift-V: paste cell above
V: paste cell below
Z: undo cell deletion
D, D: delete selected cell
Shift-M: merge selected cells, or current cell with cell below if only one cell selected
Ctrl-S: Save and Checkpoint
S: Save and Checkpoint
L: toggle line numbers
O: toggle output of selected cells
Shift-O: toggle output scrolling of selected cells
H: show keyboard shortcuts
I, I: interrupt kernel
0, 0: restart the kernel (with dialog)
Esc: close the pager
Q: close the pager
Shift-Space: scroll notebook up
Space: scroll notebook down

Edit Mode (press `Enter` to enable)

`Tab` : code completion or indent

`Shift-Tab` : tooltip

`Ctrl-]` : indent

`Ctrl-[` : dedent

`Ctrl-A` : select all

`Ctrl-Z` : undo

`Ctrl-Shift-Z` : redo

`Ctrl-Y` : redo

`Ctrl-Home` : go to cell start

`Ctrl-Up` : go to cell start

`Ctrl-End` : go to cell end

`Ctrl-Down` : go to cell end

`Ctrl-Left` : go one word left

`Ctrl-Right` : go one word right

`Ctrl-Backspace` : delete word before

`Ctrl-Delete` : delete word after

`Ctrl-M` : command mode

`Ctrl-Shift-P` : open the command palette

`Esc` : command mode

`Shift-Enter` : run cell, select below

`Ctrl-Enter` : run selected cells

`Alt-Enter` : run cell, insert below

`Ctrl-Shift--` : split cell

`Ctrl-Shift-Subtract` : split cell

`Ctrl-S` : Save and Checkpoint

`Down` : move cursor down

`Up` : move cursor up

Por qué mola el Jupyter Notebook?

porque podemos escribir texto con formato

como **este** o *este*

y tambien mates!

dentro de un texto: $\mu = \frac{\sum_{i=0}^{i=n} x_i}{n}$, por ejemplo

o como parrafo independiente

$$\mu = \frac{\sum_{i=0}^{i=n} x_i}{n}$$

o insertar enlaces e imagenes

rata topo desnuda

The Basics - Objects in Python

- Everything is an object
- Each object has an associated type, internal data and typically some attributes

- type() – get the type of an object
- isinstance() - check if an object is an instance of a particular type

- *type(a)*
- *isinstance(a, int)*
- *isinstance(a, (int, float))*

The Basics - Objects in Python

- Attributes can be:
  - other Python objects stored “inside” the object
  - methods, attached functions associated with an object which can have access to the object’s internal data.
- Attributes are accessed via the syntax: **object_name.attribute_name**

```
In [35]: a= "text"

In [36]: a.
a.capitalize  a.format      a.isupper     a.rindex      a.strip
a.center      a.index       a.join        a.rjust       a.swapcase
a.count       a.isalnum     a.ljust       a.rpartition  a.title
a.decode      a.isalpha     a.lower       a.rsplit      a.translate
a.encode      a.isdigit     a.lstrip      a.rstrip      a.upper
a.endswith    a.islower     a.partition   a.split       a.zfill
a.expandtabs  a.isspace     a.replace     a.splitlines
a.find        a.istitle     a.rfind       a.startswith
```

  - dir(), hasattr()
  - *dir(a)*
  - *hasattr(a, ‘split’)*

The Basics - Objects in Python

- object references in Python have no type associated with them.
- type information is stored in the object itself.

```
In [9]: a=5

In [10]: type(a)
Out[10]: int

In [11]: a='foo'; type(a)
Out[11]: str

In [12]: b=5/6;

In [13]: print('a is ', type(a), 'and b is', type(b))
a is  <class 'str'> and b is <class 'float'>

In [14]: print('a is %s and b is %s' %(type(a),type(b)))
a is <class 'str'> and b is <class 'float'>
```

The Basics - Objects in Python

- Python is strongly-typed language (every object has a specific type (or class))
- implicit conversions will occur only in certain obvious circumstances.

```
In [126]: 5+'5'
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-126-7e7d13df5afd> in <module>()
----> 1 5+'5'

TypeError: unsupported operand type(s) for +: 'int' and 'str'

In [127]: 5+5.3
Out[127]: 10.3

In [128]: 'as'+'vc'
Out[128]: 'asvc'
```

Scalar Types

- Main types:
  - int = Signed integer with maximum value determined by the platform.
  - long = Arbitrary precision signed integer. Large int values are automatically converted to long.
  - float = Double-precision (64-bit) floating point number. Note there is no separate double type.
  - str = String type
  - bool = A True or False value
  - None = The Python “null” value (only one instance of the None object exists)

Data structures

- lists: one-dimensional, **variable-length**, mutable sequence of Python objects
  creation:
  - using square brackets [ ]
  - by converting **any sequence or iterator** by invoking **list**()
  - [ ] = empty list

- tuple: one-dimensional, **fixed-length**, immutable sequence of Python objects (the objects CAN be mutable!!!)
  creation:
  - with a comma-separated sequence of values
  - by converting **any sequence or iterator** by invoking **tuple**()
  - ( ) = empty tuple

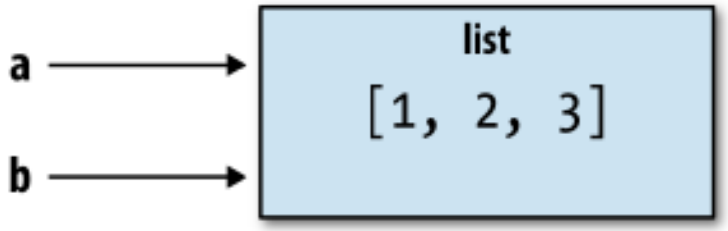
- dict: **flexibly-sized** collection of key-value pairs, where key and value are Python objects

- set: **unordered** collection of unique elements (like dicts, but keys only, no values)

Referencing an object

- When assigning a variable (or *name*) in Python, you are creating a *reference* to the object on the right hand side of the equals sign.

```
In [1]: a=[1,2,3]

In [2]: b=a

In [3]: a.append(4)

In [4]: b
Out[4]: [1, 2, 3, 4]

In [5]: id(b)
Out[5]: 139858966804384

In [6]: id(a)
Out[6]: 139858966804384

In [7]: id?
```



- When you pass objects as arguments to a function, you are only passing references; no copying occurs. (Use **.copy** if you want to copy the content of an object)

Flow Control

- Python uses whitespace (tabs or spaces) to structure code

```
for x in array:
    if x < pivot:
        less.append(x)
    else:
        greater.append(x)
```

- 4 spaces is by and large the standard adopted by the vast majority of Python programmers
- Some people use tabs or a different number of spaces, with 2 spaces not being terribly uncommon.

- Semicolons can be used, to separate multiple statements on a single line (a = 5; b = 6; c = 7)
- Comments with #

Flow Control – if -else

```
In [15]: x=-1

In [16]: if x<0:
    ...:     print('It\'s negative')
    ...:
It's negative

In [17]: if x<0:
    ...:     print('It\'s negative')
    ...: elif x==0:
    ...:     print('Equal to zero')
    ...: elif 0<x<5:
    ...:     print('positive but smaller then 5')
    ...: else:
    ...:     print('Positive and larger or equal to 5')
    ...:
It's negative
```

```
In [265]: a = 5; b = 7

In [266]: c = 8; d = 4

In [267]: if a < b or c > d:
   .....:     print "thats it"
   .....:
thats it
```

- the comparison c > d never gets evaluated because the first comparison was True.

Flow Control – for loop

- A for loop can be advanced to the next iteration, skipping the remainder of the block, using the continue keyword.

```
In [269]: sequence = [1, 2, None, 4, None, 5]

In [270]: total = 0

In [271]: for value in sequence:
   .....:     if value is None:
   .....:         continue
   .....:     total += value
   .....:

In [272]: total
Out[272]: 12
```

- A for loop can be exited altogether using the break keyword

```
In [273]: sequence = [1, 2, 0, 4, 6, 5, 2, 1]

In [274]: total_until_5 = 0

In [275]: for value in sequence:
   .....:     if value == 5:
   .....:         break
   .....:     total_until_5 += value
   .....:

In [276]: total
Out[276]: 12
```

Flow Control – while loop

- A while loop specifies a condition and a block of code that is to be executed until the condition evaluates to False or the loop is explicitly ended with break

```
In [277]: x = 256

In [278]: total = 0

In [279]: while x > 0:
   .....:     if total > 500:
   .....:         break
   .....:     total += x
   .....:     x = x // 2
   .....:

In [280]: x
Out[280]: 4

In [281]: total
Out[281]: 504
```

Functions

- declared using the def keyword and returned from using the return keyword:
- If the end of a function is reached without encountering a return statement, None is returned.

```
In [11]: def my_function(x, y, z=1.5):
    if z>1 :
        return z*(x+y)
    else:
        return z/(x+y)
   ....:
```

- Each function can have some number of positional arguments and some number of keyword arguments.
- Keyword arguments are most commonly used to specify default values or optional arguments.
- In the above function, x and y are positional arguments while z is a keyword argument.

Functions - Returning Multiple Values

- the function is actually just returning *one* object which is then being unpacked into the result variables.

```
In [6]: def f():
    a = 5
    b = 6
    c = 7
    return a, b, c
   ...:

In [7]: d, e, g = f() ;

In [8]: return_value=f()
```

Functions - Namespaces, Scope, and Local Functions

- Functions can access variables in two different scopes: global and local.

```
In [27]: def func():
    ....:     a = []
    ....:     for i in range(5):
    ....:         a.append(i)
    ....:
```

```
In [22]: a = []

In [23]: def func():
    ....:     for i in range(5):
    ....:         a.append(i)
    ....:
```

- In one option by calling func(), the empty list a is created, 5 elements are appended, then a is destroyed when the function exits. In which one?
- Assigning global variables within a function is possible, but they must be declared as global using the global keyword

```
In [41]: def bind_a_variable():
    ....:     global a
    ....:     a=[1,2]
    ....:

In [42]: bind_a_variable(); print(a)
[1, 2]
```

Functions - Namespaces, Scope, and Local Functions

- Functions can be declared anywhere, and there is no problem with having local functions

```
In [43]: def outer_function(x, y, z):
    ....:     def inner_function(a, b, c):
    ....:         pass
    ....:     pass
    ....:
```

- the inner_function will not exist until outer_function is called.
- Aa soon as outer_function is done executing, the inner_function is destroyed.

- pass is the “no-op” statement in Python. It can be used in blocks where no action is to be taken

Functions – None

- None is also a common default value for optional function arguments

```
In [673]: def add_and_maybe_multiply(a, b, c=None):
   .....:     result = a + b
   .....:     if c is not None:
   .....:         result = result * c
   .....:     return result
   .....:

In [674]: add_and_maybe_multiply(3,4)
Out[674]: 7

In [675]: add_and_maybe_multiply(3,4,2)
Out[675]: 14
```

Functions- imports

- a module is simply a .py file containing function and variable definitions
- to access the variables and functions defined:

```
# some_module.py
PI = 3.14159

def f(x):
    return x + 2

def g(a, b):
    return a + b
```

```
In [14]: import some_module

In [15]: result=some_module.f(5)

In [16]: pi=some_module.PI

In [17]: print "result=",result,", pi=",pi
result= 7 , pi= 3.14159
```

- Or equivalently:

```
In [24]: from some_module import f, g as just_another_funct, PI

In [25]: result = just_another_funct(5, PI)

In [26]: print result
8.14159
```

Quick Exercises 1

1. Implement a function that takes as input three variables, and returns the largest of the three. Do this without using the Python max() function! Make one version without any local variable and another with one local variable. (hint: it might be easier to use edit)
2. Write a function “centenario” that will take Name, and year of birth as inputs, check if year of birth is int and cast it to int if not, and print name together with the text explaining when the person is to have 100 years (hint: use isinstance)

   call to function: centenario(Antonio, 1967)

   output: Antonio will reach 100 years in 2067.

Scalar Types

- Main types:
  - int = Signed integer with maximum value determined by the platform.
  - long = Arbitrary precision signed integer. Large int values are automatically converted to long.
  - float = Double-precision (64-bit) floating point number. Note there is no separate double type.
  - str = String type
  - bool = A True or False value
  - None = The Python “null” value (only one instance of the None object exists)

Scalar Types - Numeric types

- The size of the integer which can be stored as an int is dependent on your platform (whether 32 or 64-bit), but Python will transparently convert a very large integer to long, which **can store arbitrarily large integers**.

```
In [521]: k=1423432

In [522]: k, type(k)
Out[522]: (1423432, int)

In [523]: k=12345678987987999342323

In [524]: k, type(k)
Out[524]: (12345678987987999342323L, long)

In [525]: k ** 19
Out[525]: 54800513125323773345251270381327312618370811021516443407285245980365126689197255516690150872085837363502190286655299971487823909738183098704204866549737436395629386393404477079362848446863271473432919315547193774826533364099725977658262742073732753769499763425362209369527815800889282483805755640877410037879421767536678719413015706339426325425071384576180861857832903916645271755667341759562604967994409470274108543787L
```

```
In [527]: k.
k.bit_length   k.conjugate    k.denominator  k.imag         k.numerator    k.real

In [527]: k.bit_length()
Out[527]: 74
```

Scalar Types - Numeric types

- Complex numbers are written using j for the imaginary part:

```
In [550]: cval = 1 + 2j

In [551]: (cval * (1 - 2j))*10
Out[551]: (50+0j)

In [552]: type(cval)
Out[552]: complex

In [553]: real_val=cval.real

In [554]: cval.
cval.conjugate  cval.imag       cval.real
```

Scalar Types – Strings

- You can write string literal using either single quotes ' or double quotes "
- For multiline strings with line breaks, you can use triple quotes, either ''' or """

```
In [557]: a = 'one way of writing a string'

In [558]: b = "another way"

In [559]: c = """
   .....: This is a longer string that
   .....: spans multiple lines
   .....: """
```

- strings are immutable; you cannot modify a string without creating a new string

```
In [561]: a="just another string"

In [562]: a[5]='f'
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-562-308e8794badb> in <module>()
----> 1 a[5]='f'

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

Scalar Types – Strings

- you cannot modify a string without creating a new string

```
In [563]: a
Out[563]: 'just another string'

In [564]: b=a.replace('another','changed this')

In [565]: b
Out[565]: 'just changed this string'
```

```
In [563]: a.
a.capitalize  a.find        a.isspace     a.partition   a.rstrip      a.translate
a.center      a.format      a.istitle     a.replace     a.split       a.upper
a.count       a.index       a.isupper     a.rfind       a.splitlines  a.zfill
a.decode      a.isalnum     a.join        a.rindex      a.startswith
a.encode      a.isalpha     a.ljust       a.rjust       a.strip
a.endswith    a.isdigit     a.lower       a.rpartition  a.swapcase
a.expandtabs  a.islower     a.lstrip      a.rsplit      a.title
```

Scalar Types – Strings

find = Return the lowest index where the substring is found
index = Like find() but raise ValueError when the substring is not found.

```
In [570]: a
Out[570]: 'just another string'

In [571]: a.find('o')
Out[571]: 7

In [572]: a.find('oth')
Out[572]: 7

In [573]: a.find('st')
Out[573]: 2

In [574]: a.find('sdsd')
Out[574]: -1

In [575]: a.index('sdsd')
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-575-1bd6af0a122d> in <module>()
----> 1 a.index('sdsd')

ValueError: substring not found
```

Scalar Types – Strings

- capitalize
- upper/lower
- title

```
In [578]: a
Out[578]: 'just another string'

In [579]: a.capitalize()
Out[579]: 'Just another string'

In [580]: a.upper()
Out[580]: 'JUST ANOTHER STRING'

In [581]: a.title()
Out[581]: 'Just Another String'
```

- count

```
In [582]: a.count('o')
Out[582]: 1

In [583]: a.count('r')
Out[583]: 2
```

- isdigit

```
In [592]: '5.4e-5'.isdigit()
Out[592]: False

In [593]: '23.5'.isdigit()
Out[593]: False

In [594]: '2'.isdigit()
Out[594]: True
```

Scalar Types – Strings

- split

```
In [596]: a
Out[596]: 'just another string'

In [597]: a.split(" ")
Out[597]: ['just', 'another', 'string']

In [598]: a.split("t")
Out[598]: ['jus', ' ano', 'her s', 'ring']
```

- splitlines

```
In [83]: z="first line \n continues to secod\n which might not be seen\n"

In [84]: z.splitlines()
Out[84]: ['first line ', ' continues to secod', ' which might not be seen']
```

- S.join(iterable) = Return a string which is the concatenation of the strings in the iterable. The separator between elements is S.

```
In [622]: a='just another string'

In [623]: "^".join(a)
Out[623]: 'j^u^s^t^ ^a^n^o^t^h^e^r^ ^s^t^r^i^n^g'
```

Scalar Types – Strings

- Adding two strings together concatenates them and produces a new string

```
In [650]: a = 'this is the first half '

In [651]: b= 'and this is the second half'

In [652]: a+b
Out[652]: 'this is the first half and this is the second half'
```

- Strings with a % followed by one or more format characters is a target for inserting a value into that string.

```
In [224]: template = '%.2f %s are worth $%d'

In [225]: template % (7.356000, 'Croatia Kunas', 1)
     ...:
Out[225]: '7.36 Croatia Kunas are worth $1'

In [226]: print(template %(7.356000, 'Croatia Kunas', 1))
7.36 Croatia Kunas are worth $1
```

- Strings are a sequence of characters and therefore can be treated like other sequences, such as lists and tuples

```
In [628]: s="Python is WOW"

In [629]: list(s)
Out[629]: ['P', 'y', 't', 'h', 'o', 'n', ' ', 'i', 's', ' ', 'W', 'O', 'W']
```

Scalar Types – Strings

- elements can be accessed with square brackets [ ]
- sequences are 0-indexed

```
In [23]: a='this is string'

In [24]: a[0]
Out[24]: 't'

In [25]: a[0:3]
Out[25]: 'thi'

In [26]: a[2:4]
Out[26]: 'is'

In [27]: a[4:]
Out[27]: ' is string'

In [28]: a[1:10:2]
Out[28]: 'hsi t'

In [29]: a[-1:]
Out[29]: 'g'

In [30]: a[::-1]
Out[30]: 'gnirts si siht'

In [31]: a[5::-1]
Out[31]: 'i siht'

In [32]: a[5:0:-1]
Out[32]: 'i sih'
```

Scalar Types – Booleans

- Boolean values are combined with the and and or keywords:
- Most objects in Python have a notion of true- or falseness.
- For example, empty sequences lists, dicts, tuples, etc.) are treated as False if used in control flow (as above with the empty list b).

```
In [665]: a=[]

In [666]: if a:
   .....:     print "A is not empty"
   .....: else:
   .....:     print "aaaaa... it is empty"
   .....:
aaaaa... it is empty

In [667]: (True and True) and (True or False)
Out[667]: True
```

- You can see exactly what boolean value an object has by invoking bool on it:

```
In [668]: bool([]), bool([1, 2, 3])
Out[668]: (False, True)
```

```
In [670]: a=None; b=5

In [671]: a is None, b is not None
Out[671]: (True, True)
```

Scalar Types – Type casting

- The str, bool, int and float types are also functions which can be used to cast values to those types

```
In [660]: a="345"

In [661]: str(a)
Out[661]: '345'
```

```
In [687]: s = '3.14159'

In [688]: fval = float(s)

In [689]: type(fval)
Out[689]: float

In [690]: int(fval)
Out[690]: 3

In [691]: bool(fval)
Out[691]: True

In [692]: bool('0')
Out[692]: True

In [693]: bool(0)
Out[693]: False
```

Quick Exercises 2

1. Write a function to calculate the number of words, number of lines, and length of a string the same way the wc command does in the command line
2. Write a Python program to remove the n^{th} index character from a string. If the input string is empty print warning.

The shell commands

- We have shell with ! command
- Tab also works
- IMPORTANT!! The shell where !command runs is immediately discarded after executing 'command'.

```
In [40]: ! pwd
/home/dsc/python_class

In [41]: ! ls -l
total 180
-rw-rw-r--. 1 dsc dsc    95 Apr  4 12:35 hello_world.py
-rw-rw-r--. 1 dsc dsc   212 Apr  6 08:09 say_hello.py.py
-rw-rw-r--. 1 dsc dsc    84 Apr  4 14:34 some_module.py
-rw-rw-r--. 1 dsc dsc   362 Apr  4 14:36 some_module.pyc
-rw-rw-r--. 1 dsc dsc 43675 Apr  6 10:15 test01.ipynb
-rw-rw-r--. 1 dsc dsc  5422 Apr  5 20:17 test03.ipynb
-rw-rw-r--. 1 dsc dsc 89812 Apr  5 22:50 test2.ipynb
-rw-rw-r--. 1 dsc dsc 20208 Apr  5 09:31 test2.ipynb.01
-rw-rw-r--. 1 dsc dsc     0 Apr  5 13:17 test.txt
-rw-rw-r--. 1 dsc dsc   582 Apr  5 22:23 Untitled.ipynb

In [42]: ! cat h
%%html          %history        hash            help
%hist           hasattr         hello_world.py  hex

In [42]: ! cat hello_world.py
```

The shell commands

```
In [42]: ! grep -i "hello" hello_world.py
print 'Hello world from python!'

In [43]: ! grep "hello" hello_world.py

In [44]: ! psql -d optd
psql (9.4.6)
Type "help" for help.

optd=# \d
                  List of relations
 Schema |               Name                | Type  | Owner
--------+-----------------------------------+-------+-------
 public | airports                          | table | dsc
 public | continents                        | table | dsc
```

- Run python from within python

```
In [46]: !python hello_world.py
Hello world from python!

In [47]: %run hello_world.py
Hello world from python!
```

The shell commands

- Try cd command!

It fails silently….. Why doesn't it work?

```
In [61]: ! pwd
/home/dsc/python_class

In [62]: ! cd ..

In [63]: ! pwd
/home/dsc/python_class

In [64]: %cd -
/home/dsc

In [65]: ! pwd
/home/dsc
```

What did we use instead? Magic ☺

- %dhist, _dh
- *cd -1*

The Magic commands

- IPython has a set of predefined ‘magic functions’
- Line magics are prefixed with the %
- Functions that get as an argument the rest of the line, where arguments are passed without parentheses or quotes.

```
In [10]: %lsmagic
Out[10]:
Available line magics:
%alias  %alias_magic  %autocall  %autoindent  %automagic  %bookmark  %cat  %cd  %clear
%colors  %config  %cp  %cpaste  %debug  %dhist  %dirs  %doctest_mode  %ed  %edit  %env
%gui  %hist  %history  %install_default_config  %install_ext  %install_profiles  %killbg
scripts  %ldir  %less  %lf  %lk  %ll  %load  %load_ext  %loadpy  %logoff  %logon  %logst
art  %logstate  %logstop  %ls  %lsmagic  %lx  %macro  %magic  %man  %matplotlib  %mkdir
 %more  %mv  %notebook  %page  %paste  %pastebin  %pdb  %pdef  %pdoc  %pfile  %pinfo  %p
info2  %popd  %pprint  %precision  %profile  %prun  %psearch  %psource  %pushd  %pwd  %p
ycat  %pylab  %quickref  %recall  %rehashx  %reload_ext  %rep  %rerun  %reset  %reset_se
lective  %rm  %rmdir  %run  %save  %sc  %set_env  %store  %sx  %system  %tb  %time  %tim
eit  %unalias  %unload_ext  %who  %who_ls  %whos  %xdel  %xmode
```

The Magic commands

- Cell magics are prefixed with a double %%,
- Functions that get as an argument not only the rest of the line, but also the lines below it in a separate argument.

```
Available cell magics:
%%!  %%HTML  %%SVG  %%bash  %%capture  %%debug  %%file  %%html  %%javascript  %%latex  %
%perl  %%prun  %%pypy  %%python  %%python2  %%python3  %%ruby  %%script  %%sh  %%svg  %%
sx  %%system  %%time  %%timeit  %%writefile
```

```
In [237]: %%bash
   .....: ls -l
   .....: grep -i "hello" *.py
   .....:
total 180
-rw-rw-r--. 1 dsc dsc    95 Apr  4 12:35 hello_world.py
-rw-rw-r--. 1 dsc dsc   212 Apr  6 08:09 say_hello.py.py
-rw-rw-r--. 1 dsc dsc    84 Apr  4 14:34 some_module.py
-rw-rw-r--. 1 dsc dsc   362 Apr  4 14:36 some_module.pyc
-rw-rw-r--. 1 dsc dsc 43675 Apr  6 10:15 test01.ipynb
-rw-rw-r--. 1 dsc dsc  5422 Apr  5 20:17 test03.ipynb
-rw-rw-r--. 1 dsc dsc 89812 Apr  5 22:50 test2.ipynb
```

Line Magic commands

- %automagic = Make magic functions callable without having to type the initial %.
- %cd = Change the current working directory
- %dhist = Print your history of visited directories.

- %run -Run the named file inside IPython as a program.
- %quickref = Show a quick reference cheat sheet

- %matplotlib = Set up matplotlib to work interactively.
    - %matplotlib inline
- %precision : Set floating point precision for pretty printing.

```
In [9]: 10/3.
Out[9]: 3.3333333333333335

In [10]: %precision 3
Out[10]: u'%.3f'

In [11]: 10/3.
Out[11]: 3.333
```

Line Magic commands

- %config = configure ipython
  - To see what classes are available for config, pass no arguments
  - To view what is configurable on a given class, just pass the class name:
  - To view one parameter pass class_name.parameter
  - To change the parameter: config TerminalInteractiveShell.editor='kwrite'
  - echo “export EDITOR=kwrite” >>~/.zshrc

```
In [16]: config
Available objects for config:
     TerminalInteractiveShell
     HistoryManager
     PrefilterManager
     IPCompleter
     PromptManager
     DisplayFormatter
     MagicsManager
     ScriptMagics
     AliasManager
     TerminalIPythonApp
     StoreMagics
     StoreMagics

In [17]: config TerminalInteractiveShell.editor
Out[17]: u'vi'

In [18]: config TerminalInteractiveShell.editor='gedit'

In [19]: config TerminalInteractiveShell.editor
Out[19]: u'gedit'
```

Line Magic commands

- %history = Print input history, with most recent last.
  - -n print line numbers for each input.
  - -o also print outputs for each input.
  - -l ‘n’ get the last n lines from all sessions. (the default is the last 10 lines)
  - -g show full saved history
  - -f +FILE save it to file

  - **Exercise**
    - 4 = Line 4, current session
    - 4-6 = Lines 4-6, current session
    - 23/1-5 = Lines 1-5, session 23
    - ~2/7 = Line 7, 2 sessions previous to the current
    - ~8/1-~6/5 = From the first line of 8 sessions ago, to the fifth line of 6 sessions ago.

The same syntax is used by %macro, %save, %edit, %rerun

Line Magic commands

- %edit = Bring up an editor and execute the resulting code
  - -x do not execute the edited code immediately upon exit.

```
In [7]: x=3; y=5

In [8]: print x+y
8

In [9]: edit 7-8
IPython will make a temporary file named: /tmp/ipython_edit_rwnYmf/ipython_edit_0f71H5.py
Editing... done. Executing edited code...
8
Out[9]: 'x=3; y=5\nprint x+y\n'

In [10]: edit /tmp/ipython_edit_rwnYmf/ipython_edit_0f71H5.py
Editing... done. Executing edited code...
8
Out[10]: 'x=3; y=5\nprint x+y\n'
```

Line Magic commands

- %edit = Bring up an editor and execute the resulting code
  - -x do not execute the edited code immediately upon exit.

```
In [66]: def my_func():
    ...:     pass
    ...:

In [67]: edit my_func
Editing In[66]
IPython will make a temporary file named: /tmp/ipython_edit_9pfxudfs/ipython_edit_jygwequg.py
Editing... done. Executing edited code...
Out[67]: 'def my_func():\n    pass'
```

- Workflow: edit, run, edit
- pass is the “no-op” statement in Python. It can be used in blocks where no action is to be taken

Line Magic commands

- %rerun = Re-run previous input
  - -l <n> : Repeat last n lines of input, not including the current.

- %save [FILE] + cells= save input
  - -a =append
  - -f = force

```
In [29]: rerun 24-26
=== Executing: ===
x=1
y=2
print(x+y)
=== Output: ===
3
```

Line Magic commands

- %macro = Define a macro for future re-execution.

```
In [24]: x=1

In [25]: y=2

In [26]: print(x+y)
3

In [27]: macro my_first_macro 24-26
Macro `my_first_macro` created. To execute, type its name (without quotes).
=== Macro contents: ===
x=1
y=2
print(x+y)

In [28]: my_first_macro
3
```

Line Magic commands

- %who = Print all interactive variables, with some minimal formatting.
- %who_ls = Return a sorted list of all interactive variables
- %whos = Like %who, but gives some extra information about each variable.

- %xdel = Delete a variable

- %reset = Resets the namespace by removing all names defined by the user

Line Magic commands

- %who = Print all manually defined variables, with some minimal formatting.
  - excludes names loaded through configuration file and things which are internal to IPython.
  - If any arguments are given, only variables whose type matches one of these are printed.

```
In [104]: who
abs      func    my_first_macro  my_first_macrto        simple_f       x       x_plus  y       z


In [105]: who int
x       y       z

In [106]: who int function
abs      func    simple_f       x       x_plus  y       z

In [107]: who function str
abs      func    simple_f       x_plus
```

Line Magic commands

- %whos = Like %who, but gives some extra information about each variable.
- %who_ls = Return a sorted list of all manually defined variables

```
In [114]: whos
Variable           Type        Data/Info
-------------------------------------
abs                function    <function abs at 0x7fcd31d495f0>
func               function    <function func at 0x7fcd31d49aa0>
my_first_macro     Macro       x=1\ny=2\nprint(x+y)\n
my_first_macrto    Macro       x=1\ny=2\nz=x+y\nprint z\n
simple_f           function    <function simple_f at 0x7fcd31d496e0>
x                  int         3
x_plus             function    <function x_plus at 0x7fcd31d49ed8>
y                  int         5
z                  int         3

In [115]: whos Macro
Variable           Type     Data/Info
---------------------------------
my_first_macro     Macro    x=1\ny=2\nprint(x+y)\n
my_first_macrto    Macro    x=1\ny=2\nz=x+y\nprint z\n
```

```
In [108]: who_ls
Out[108]:
['abs',
 'func',
 u'my_first_macro',
 u'my_first_macrto',
 'simple_f',
 'x',
 'x_plus',
 'y',
 'z']

In [109]: who_ls int
Out[109]: ['x', 'y', 'z']
```

Line Magic commands

- %xdel = Delete a variable, the object **and references held under other names**
- try del command! What is the difference?

```
In [42]: k=5; a=k

In [43]: who
a         add_one         k       x       y

In [44]: xdel a

In [45]: who
add_one  x       y
```

- %reset = Resets the namespace by removing all names defined by the user

```
In [138]: reset
Once deleted, variables cannot be recovered. Proceed (y/[n])? y

In [139]: who
Interactive namespace is empty.
```

Line Magic commands

- **capturing the output of shell command**

```
In [211]: a= ! ls *py

In [212]: a
Out[212]: ['hello_world.py', 'say_hello.py.py', 'some_module.py']

In [213]: b=!cat hello_world.py
```

- Which type is the output?
- What methods does it have?

```
In [220]: type(a)
Out[220]: IPython.utils.text.SList

In [221]: a.
a.append     a.fields     a.get_paths  a.index      a.list       a.p          a.remove     a.sort
a.count      a.get_list   a.get_spstr  a.insert     a.n          a.paths      a.reverse    a.spstr
a.extend     a.get_nlstr  a.grep       a.l          a.nlstr      a.pop        a.s

In [221]: a.grep?
```

Line Magic commands

- The output capture has the following special attributes:
  - .l (or .list) : value as list.
  - .n (or .nlstr): value as newline-separated string.
  - .s (or .spstr): value as space-separated string.

- Can we reuse this for the input of another magic command? YES!

```
In [230]: a.s
Out[230]: 'hello_world.py say_hello.py.py some_module.py'

In [231]: !wc -l $a.s
 12 hello_world.py
  5 say_hello.py.py
  9 some_module.py
 26 total
```

Handling Files

- Most of time we use high-level tools like pandas.read_csv to read data files from disk into Python data structures.
- However …
- open(path) - by default, the file is opened in read-only mode 'r'.

```
In [390]: path='Finn.txt'

In [391]: f=open(path)

In [392]: f2=open('abx.txt','w')

In [393]: f.
f.close       f.fileno      f.name        f.readinto    f.softspace   f.writelines
f.closed      f.flush       f.newlines    f.readline    f.tell        f.xreadlines
f.encoding    f.isatty      f.next        f.readlines   f.truncate
f.errors      f.mode        f.read        f.seek        f.write
```

- **We can then treat the file handle f like a list and iterate over the lines!**

```
In [394]: for lines in f:
   .....:     #TODO make smth
   .....:     pass
   .....:
```

curl -s http://www.gutenberg.org/cache/epub/76/pg76.txt > Finn.txt

Handling Files

- **fopen** modes:
  - r Read-only mode
  - w Write-only mode. Creates a new file (deleting any file with the same name)
  - a Append to existing file (create it if it does not exist)
  - r+ Read and write
  - b Add to mode for binary files, that is 'rb' or 'wb'
- file handler methods
  - **read**([size]) Return data from file as a string, with optional size argument indicating the number of bytes to read
  - **readlines**([size]) Return list of lines in the file, with optional size argument
  - **write**(str) Write passed string to file.
  - **writelines**(strings) Write passed sequence of strings to the file.
  - **close**() Close the handle
  - **flush**() Flush the internal I/O buffer to disk
  - **seek**(pos) Move to indicated file position (integer).
  - **tell**() Return current file position as integer.
  - **closed** True if the file is closed.

Quick Exercises 3

1. While inside python, go to ~/Data/opentraveldata/ and list the files. Repeat the same for /home/dsc/Data/us_dot/otp and ~/Data/us_dot/traffic/.

   Use the list of visited directories from dhist and write for loop which will return for each visited directory its name and number of files inside.

2. Write a function that will take text file and pattern as input parameters, and return the number of occurances of case insensitive pattern inside a text (similar to: grep -i –o pattern file | wc -l)
3. Open Finn.txt file, read lines into a list. Remove trailing white spaces from each line . Write the resulting list to the new file. How many lines does the new file have? (hint: empty list is made with [ ])
4. Open Finn.txt file, read lines into a list. Create a new version of Finn_nbl.txt with no blank lines.
5. Reset the workspace. Obtain the difference in number of lines between original Finn file and and the one without blank lines and print the result. (hint: use wc)

Data structures

- lists: one-dimensional, **variable-length**, mutable sequence of Python objects
  creation:
  - using square brackets [ ]
  - by converting **any sequence or iterator** by invoking **list**()
  - [ ] = empty list

- tuple: one-dimensional, **fixed-length**, immutable sequence of Python objects (the objects CAN be mutable!!!)
  creation:
  - with a comma-separated sequence of values
  - by converting **any sequence or iterator** by invoking **tuple**()
  - ( ) = empty tuple

- dict: **flexibly-sized** collection of key-value pairs, where key and value are Python objects

- set: **unordered** collection of unique elements (like dicts, but keys only, no values)

Data structures - Lists

- lists: one-dimensional, **variable-length**, mutable sequence of Python objects

- creation:
  - using square brackets [ ]
  - by converting **any sequence or iterator** by invoking list()
  - [ ] = empty list

- can be nested

```
In [106]: a_list=[2,3,None, 7]

In [107]: a_list
Out[107]: [2, 3, None, 7]

In [108]: b_list=a_list+a_list

In [109]: b_list
Out[109]: [2, 3, None, 7, 2, 3, None, 7]

In [110]: c_list=list([a_list, a_list])

In [111]: c_list
Out[111]: [[2, 3, None, 7], [2, 3, None, 7]]

In [112]: c_list[0][1]
Out[112]: 3
```

- **Lists and tuples** are semantically similar as one-dimensional sequences of objects and thus **can be used interchangeably in many functions**

Data structures - Lists

- Adding and removing elements
  - append(S) = add element S at the end
  - extend([ ]) = append multiple elements
  - insert(N,S) = insert element S at position N
  - remove(S) = removes the first occurrence of S from the list
  - pop(N) = remove and return element at position N

```
In [1080]: a=['I','live', 'in']

In [1081]: a.append('Madrid')

In [1082]: a=a+['since','2012']

In [1083]: a
Out[1083]: ['I', 'live', 'in', 'Madrid', 'since', '2012']

In [1084]: a.pop(2);a.pop(2);

In [1085]: a
Out[1085]: ['I', 'live', 'since', '2012']

In [1086]: a.insert(2,'here')

In [1091]: a
Out[1091]: ['I', 'live', 'here', 'since', '2012', 'here']

In [1092]: a.remove('here')

In [1093]: a
Out[1093]: ['I', 'live', 'since', '2012', 'here']

In [1094]: 'test' in a
Out[1094]: False

In [1095]: a.extend(['in','Madrid.'])

In [1096]: a
Out[1096]: ['I', 'live', 'since', '2012', 'here', 'in', 'Madrid.']
```

- insert is computationally expensive compared with append as references to subsequent elements have to be shifted internally to make room for the new element.

Data structures - Lists

- List concatenation (with +) is a more expensive operation then extend() since a new list must be created and the objects copied over.

```
everything = [ ]
for chunk in list_of_lists:
    everything.extend(chunk)
```

Vs.

```
everything = [ ]
for chunk in list_of_lists:
    everything = everything + chunk
```

- Using extend to append elements to an existing list is preferable especially if you are building up a large list!!!

Data structures - Lists

- reverse() = reverses objects of list in place
- sort (key=method, reverse=True/False) = in-place sorting based on key method

```
In [1168]: a = [7, 2, 5, 1, 3]

In [1169]: a.sort(); a
Out[1169]: [1, 2, 3, 5, 7]

In [1170]: b = ['Hello', 'small', 'helll', 'foxes', 'he', 'Man']

In [1171]: b.sort(); b
Out[1171]: ['Hello', 'Man', 'foxes', 'he', 'helll', 'small']

In [1172]: b.sort(key=str); b
Out[1172]: ['Hello', 'Man', 'foxes', 'he', 'helll', 'small']

In [1173]: b.sort(key=str.lower);b
Out[1173]: ['foxes', 'he', 'helll', 'Hello', 'Man', 'small']

In [1174]: b.sort(key=len,reverse=True);b
Out[1174]: ['foxes', 'helll', 'Hello', 'small', 'Man', 'he']

In [1175]: b.sort(key=lambda x:x.count('l'));b
Out[1175]: ['foxes', 'Man', 'he', 'Hello', 'small', 'helll']
```

Data structures - Lists

- sorted (list, key=method, reverse=True/False)
  - works on any iterable

```
In [1208]: c=sorted(b, key=lambda x:x.count('l'))

In [1209]: c
Out[1209]: ['Madrid', 'in', 'I', 'live']

In [1210]: a=1,24,5,67,7,4,34

In [1211]: sorted(a)
Out[1211]: [1, 4, 5, 7, 24, 34, 67]
In [1219]: sorted('say hy')
Out[1219]: [' ', 'a', 'h', 's', 'y', 'y']
```

Functions - Anonymous Functions

- or *lambda* functions
- **simple functions consisting of a single statement, the result of which is the return value.**
- defined using the lambda keyword, which has no meaning other than “we are declaring an anonymous function.”

```
In [24]: def short_function(x):
    ....:     return x * 2
    ....:

In [25]: equiv_anon = lambda x: x * 2
```

- They are especially convenient in data analysis because, there are many cases where data transformation functions will take functions as arguments (as we have seen in the previous slide).

```
In [28]: def apply_to_list(some_list, f):
    ....:     return [f(x) for x in some_list]
    ....:

In [29]: ints = [4, 0, 1, 5, 6]

In [30]: apply_to_list(ints, lambda x: x * 2)
Out[30]: [8, 0, 2, 10, 12]
```

Functions - Are Objects

- function is used as argument to other function
- ops has a list of the operations to apply to a particular set of values

```
In [12]: def add_one(value):
    ....:     return value+1
    ....:

In [13]: def double_value(value):
    ....:     return value*2
    ....:

In [14]: def add_three(value):
    ....:     return value+3
    ....:

In [15]: math_ops = [add_one, double_value, add_three]
```

```
In [17]: def math_values(values, ops):
    result = []
    for value in values:
        for function in ops:
            value = function(value)
        result.append(value)
    return result
    ....:

In [18]: k=[1,2,3]

In [19]: math_values(k, math_ops)
Out[19]: [7, 9, 11]
```

- map is built in function which applies a function to a collection of some kind

```
In [21]: k
Out[21]: [1, 2, 3]

In [22]: map(add_one, k)
Out[22]: [2, 3, 4]
```

Data structures - Tuples

- tuple: one-dimensional, **fixed-length**, immutable sequence of Python objects (the objects CAN be mutable!!!)
- creation:
  - with a comma-separated sequence of values
  - by converting **any sequence or iterator** by invoking tuple()
  - ( ) = empty tuple
- can be nested

```
In [712]: tup = 4, 5, 6

In [713]: tup
Out[713]: (4, 5, 6)

In [714]: tup = tuple('string')

In [715]: tup
Out[715]: ('s', 't', 'r', 'i', 'n', 'g')

In [716]: tuple([4, 0, 2])
Out[716]: (4, 0, 2)

In [717]: nested_tup = (4, 5, 6), (7, 8), ('A',8,'abcd');

In [718]: nested_tup
Out[718]: ((4, 5, 6), (7, 8), ('A', 8, 'abcd'))
```

Data structures - Tuples

- elements can be accessed with square brackets [ ]
- sequences are 0-indexed

```
In [744]: tup = tuple('string')

In [745]: tup[0]
Out[745]: 's'

In [746]: tup[:3]
Out[746]: ('s', 't', 'r')

In [747]: tup[2:4]
Out[747]: ('r', 'i')

In [748]: tup[4:]
Out[748]: ('n', 'g')

In [749]: tup[1:5:2]
Out[749]: ('t', 'i')
```

Data structures - Tuples

- **In tuple it is not possible to modify the position of object**
- But… the objects stored in a tuple may be mutable themselves, once created!!!

```
In [792]: tup = tuple(['foo', [1, 2], True])

In [793]: tup[2]=False
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-793-b2aa2cf1b676> in <module>()
----> 1 tup[2]=False

TypeError: 'tuple' object does not support item assignment

In [794]: tup[3]=123
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-794-e354dbc1d7ea> in <module>()
```

```
In [808]: tup = tuple(['foo', [1, 2], True])

In [809]: tup[1].append(23)

In [810]: tup[1].insert(1,14)

In [811]: tup
Out[811]: ('foo', [1, 14, 2, 23], True)
```

Data structures - Tuples

- Tuples can be concatenated using the + operator to produce longer tuples

```
In [847]: tup = tuple(['foo', [1, 2], True])

In [848]: tup = tup + tuple([23,45])+tuple([[23,45]])+tuple('Askme')+tuple(['Answer'])

In [849]: tup
Out[849]: ('foo', [1, 2], True, 23, 45, [23, 45], 'A', 's', 'k', 'm', 'e', 'Answer')

In [850]: tup +=tuple([True])
```

- Multiplying a tuple by an integer, has the effect of concatenating together that many copies of the tuple.

```
In [853]: tup
Out[853]: ('foo', [1, 2], True)

In [854]: tup *2
Out[854]: ('foo', [1, 2], True, 'foo', [1, 2], True)
```

Data structures - Tuples

- Be careful when creating tuples the objects themselves are not copied, only the references to them.
- What has happen to scalar types?

```
In [872]: a= [1,2,3]; b=[23]; c=50; d=['Txt']; e='a'

In [873]: tup=tuple([a,b,c,d,e])

In [874]: tup2=tup*2

In [875]: a[0]=4; b.append(-23); c=7; d[0]='yes'; e='aa5'

In [876]: tup2
Out[876]:
([4, 2, 3],
 [23, -23],
 50,
 ['yes'],
 'a',
 [4, 2, 3],
 [23, -23],
 50,
 ['yes'],
 'a')
```

Data structures - Tuples

- Unpacking tuples

```
In [929]: tup = (4, 5, 6)

In [930]: a, b, c = tup

In [931]: b
Out[931]: 5

In [932]: tup = 4, 5, (6, 7)

In [933]: a, b, (c, d) = tup

In [934]: d
Out[934]: 7

In [935]: a, b, cd = tup

In [936]: cd
Out[936]: (6, 7)
```

- Using this functionality it's easy to swap variable names

```
In [940]: a,b
Out[940]: (5, 4)

In [941]: a,b=b,a

In [942]: a,b
Out[942]: (4, 5)
```

Data structures - Tuples

- Methods :
  - index() = return first index of value
  - count() = counts the number of occurrences of a value

```
In [956]: a = (1, 2, 2, 2, 3, 4, 2)

In [957]: a.count(2)
Out[957]: 4

In [958]: a.index(2)
Out[958]: 1

In [959]: 565 in a
Out[959]: False

In [960]: b=('this', 'is', 'my', 'home')

In [961]: b.count('i')
Out[961]: 0

In [962]: b.count('is')
Out[962]: 1

In [963]: b.count('isd')
Out[963]: 0

In [964]: b.index('isd')
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
```

Quick Excercises 4

1. For a sequence [1, 2, 3, 4, 5, 6, 7, 8] get the squared values using the lambda function.
2. Prepare a list with 10 names. Make a code that will put all vowels to capitals and every other character to lower letters.
3. Prepare again a list with 10 names. Make a function with two input variables: list, and character; that returns a list of names containing one or more of input characters ’s inside the name.
4. Reverse word order from the input string
5. Create a function that accepts string as search string and returns number of lines with that string in a command history (hint : use a in b)
6. Write a Python function that takes a list of words and returns the length of the longest one.

We need this to proceed - Enumerate

- It's common when iterating over a sequence to want to keep track of the index of the current item
- enumerate() returns a sequence of (i, value) tuples

```
In [7]: counter=0

In [8]: for val in range(10,20):
   ...:     print(counter, val)
   ...:     counter +=1
   ...:
0 10
1 11
2 12
3 13
4 14
5 15
6 16
7 17
8 18
9 19
```

```
In [9]: for i, val in enumerate(range(10,20)):
   ...:     print(i,val)
   ...:
0 10
1 11
2 12
3 13
4 14
5 15
6 16
7 17
8 18
9 19
```

```
for i, val in enumerate(reversed(range(10,20))):
    print(i,val)
```

- useful especially when constructing a dict
- reversed() = iterates over the elements of a sequence in reverse order

We need this to proceed - Zip

```
In [42]: seq1=1,2,3,4

In [43]: seq2=[5,6,7,8]

In [44]: seq3=[True, False, True]

In [45]: table=zip(seq1,seq2,seq3)

In [46]: type(table)
Out[46]: zip

In [47]: list(table)
Out[47]: [(1, 5, True), (2, 6, False), (3, 7, True)]

In [48]: list(table)
Out[48]: []

In [49]: table=zip(seq1,seq2,seq3)

In [50]: for i, val in enumerate(table):
    ...:     print(i, val)
    ...:
0 (1, 5, True)
1 (2, 6, False)
2 (3, 7, True)

In [51]: table=zip(seq1,seq2,seq3)

In [52]: for i, (val1,val2,val3) in enumerate(table):
    ...:     print(i,val1,val2,val3)
    ...:
0 1 5 True
1 2 6 False
2 3 7 True
```

- "pairs" up the elements of a number of lists,tuples, or other sequences, to create a list of tuples
- pairing is ended when the shortest sequence is exhausted
- returns a zip object which is in fact an iteretor

- uzip is also done with zip()

```
In [54]: table=zip(seq1,seq2,seq3)

In [55]: seq1,seq2,seq3=zip(*table)

In [56]: list(seq1)
Out[56]: [1, 2, 3]
```

Data structures - Dicts

- dict: **flexibly-sized** collection of key-value pairs, where key and value are Python objects
- A more common name for it is hash map or associative array.

- creation:
  - curly braces { } and using colons **:** to separate keys and values
  - by using dict() method over (key, value) pairs
  - { } = empty dict

```
In [66]: dict(key1=1, key2=2)
Out[66]: {'key1': 1, 'key2': 2}

In [67]: dict((('key1',2),('key2',2)))
Out[67]: {'key1': 2, 'key2': 2}

In [68]: dict([('key1',2),('key2',2)])
Out[68]: {'key1': 2, 'key2': 2}

In [69]: dict([['key1',2],['key2',2]])
Out[69]: {'key1': 2, 'key2': 2}

In [70]: values=(1,2,3,4)

In [71]: keys=('a','b','c')

In [72]: dict(zip(keys,values))
Out[72]: {'a': 1, 'b': 2, 'c': 3}

In [73]: {'a':2, 'keyB':3}
Out[73]: {'a': 2, 'keyB': 3}
```

Data structures - Dicts

- Elements can be accessed , inserted or set using the same syntax as accessing elements of a list or tuple

```
In [1358]: d1 = {'a' : 'some value', 'b' : [1, 2, 3, 4]}

In [1359]: d1['St'] = 'Split'; d1[4]='integer'

In [1360]: d1[4]
Out[1360]: 'integer'

In [1361]: del d1['a']

In [1362]: d1
Out[1362]: {4: 'integer', 'St': 'Split', 'b': [1, 2, 3, 4]}

In [1363]: a=d1.pop('St')

In [1364]: a
Out[1364]: 'Split'

In [1365]: d1
Out[1365]: {4: 'integer', 'b': [1, 2, 3, 4]}
```

Data structures - Dicts

```
In [1381]: d1
Out[1381]: {'a': 'some value', 'b': [1, 2, 3, 4]}

In [1382]: d1.
d1.clear       d1.get         d1.iteritems   d1.keys        d1.setdefault  d1.viewitems
d1.copy        d1.has_key     d1.iterkeys    d1.pop         d1.update      d1.viewkeys
d1.fromkeys    d1.items       d1.itervalues  d1.popitem     d1.values      d1.viewvalues
```

- clear() = Remove all items from dict
- get(S, V) = search for S, and return V if you don't find it
- keys() = lists of the keys
- values() = lists of the values
- update(D) = merged into and overwrite if key already exists

```
In [1384]: d1
Out[1384]: {'a': 'some value', 'b': [1, 2, 3, 4]}

In [1385]: d1.get('Spu','Not inside')
Out[1385]: 'Not inside'

In [1386]: d1.keys(), d1.values()
Out[1386]: (['a', 'b'], ['some value', [1, 2, 3, 4]])

In [1387]: d2={'b':'as you see', 5:'second integer'}

In [1388]: d1.update(d2)

In [1389]: d1
Out[1389]: {5: 'second integer', 'a': 'some value', 'b': 'as you see'}
```

Functions - Returning Multiple Values

- alternative to returning multiple values might be to return a dict instead:

```
In [9]: def f():
   ...:     a = 5
   ...:     b = 6
   ...:     c = 7
   ...:     return {'a' : a, 'b' : b, 'c' : c}
   ...:

In [10]: return_value=f()

In [11]: return_value
Out[11]: {'a': 5, 'b': 6, 'c': 7}
```

Data structures - Sets

- set: **unordered** collection of unique elements (like dicts, but keys only, no values)
- like dicts, but keys only, no values

- creation:
  - curly braces { } (no colons inside as no keys are present)
  - by using set() method
  - set()= empty set
    set({ })= set({[ ])=set(())=set()

```
In [6]: a=set([2, 2, 2, 1, 3, 3])

In [7]: b={2, 2, 2, 1, 3, 3}

In [8]: type(a), type(b)
Out[8]: (set, set)

In [9]: a
Out[9]: {1, 2, 3}

In [10]: b
Out[10]: {1, 2, 3}

In [11]: c=set({})

In [12]: c
Out[12]: set()
```

Data structures - Sets

- support mathematical *operations* like:
  - a.union(b) = a | b
  - a.intersection(b) = a & b
  - a.difference(b) = a - b
  - a.symmetric_difference(b) = a ^ b

```
In [16]: a = {1, 2, 3, 4, 5}

In [17]: b = {3, 4, 5, 6, 7, 8}

In [18]: a | b # union (or)
Out[18]: {1, 2, 3, 4, 5, 6, 7, 8}

In [19]: a & b # intersection (and)
Out[19]: {3, 4, 5}

In [20]: a - b # difference
Out[20]: {1, 2}

In [21]: a ^ b # symmetric difference (xor)
Out[21]: {1, 2, 6, 7, 8}
```

Data structures - Sets

- You can also check if a set is a subset of (is contained in) or a superset of (contains all elements of) another set:
- sets are equal if their contents are equal

```
In [27]: a_set = {1, 2, 3, 4, 5}

In [28]: {3, 2, 1}.issubset(a_set)
Out[28]: True

In [29]: a_set.issuperset({2, 1, 3})
Out[29]: True

In [30]: {1, 2, 3} == {3, 2, 1}
Out[30]: True
```

- Other methods

```
In [14]: c
Out[14]: set()

In [15]: c.
c.add                       c.intersection              c.remove
c.clear                     c.intersection_update       c.symmetric_difference
c.copy                      c.isdisjoint                c.symmetric_difference_update
c.difference                c.issubset                  c.union
c.difference_update         c.issuperset                c.update
c.discard                   c.pop
```

Nice to know– Comprehensions

- List comprehensions allow to concisely form a new list by filtering the elements of a collection and transforming the elements passing the filter in one concise expression.

[expr for val in collection *if condition*] **=**

```
result = [ ]
for val in collection:
    if condition:
        result.append(expr)
```

```
In [51]: strings = ['a', 'as', 'bat', 'car', 'dove', 'python']

In [52]: [x.upper() for x in strings if len(x) > 2]
Out[52]: ['BAT', 'CAR', 'DOVE', 'PYTHON']
```

Nice to know– Comprehensions

- Dict and set comprehensions:

dict_comp = {key-expr : value-expr for value in collection *if condition*}

set_comp = {*expr* for value in collection *if condition*}

```
In [53]: unique_lengths = {len(x) for x in strings}

In [54]: unique_lengths
Out[54]: {1, 2, 3, 4, 6}

In [55]: loc_mapping = {val : index for index, val in enumerate(strings)}

In [56]: loc_mapping
Out[56]: {'a': 0, 'as': 1, 'bat': 2, 'car': 3, 'dove': 4, 'python': 5}

In [57]: loc_mapping2 = dict((val, idx) for idx, val in enumerate(strings))

In [58]: loc_mapping2
Out[58]: {'a': 0, 'as': 1, 'bat': 2, 'car': 3, 'dove': 4, 'python': 5}
```

Nice to know– Comprehensions

- nested list comprehensions are a bit hard to wrap your head around.
- The for parts of the list comprehension are arranged according to the order of nesting,
- filter condition is put at the end as before.
- *example where we "flatten" a list of tuples of integers into a simple list of integers:*

```
In [63]: some_tuples = [(1, 2, 3), (4, 5, 6), (7, 8, 9)]

In [64]: flattened = [x for tup in some_tuples for x in tup]

In [65]: flattened
Out[65]: [1, 2, 3, 4, 5, 6, 7, 8, 9]

In [66]: flattened2 = []

In [67]: for tup in some_tuples:
   ....:     for x in tup:
   ....:         flattened2.append(x)
   ....:

In [68]: flattened2
Out[68]: [1, 2, 3, 4, 5, 6, 7, 8, 9]
```

- Keep in mind that the order of the for expressions would be the same if you wrote a nested for loop instead of a list comprehension

Quick Excercises 5

1. Categorize a list of words by their first letter, meaning that the result of the operation is first letter and all the words from the input list starting with that letter. (hint: use dict)
2. Sort a collection of strings by the number of distinct letters in each string. (hint: use set and lambda)
3. Reverse word order from the input string by using for comprehension