Introduction to Python

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What is Python?

Python is a programming language created by Guido van Rossum in 1991.

It is a high level, interpreted, dynamic typed, strong typed, garbage collected language, supporting imperative, functional, and object oriented programming styles.

The name comes after the Monty Python Flying Circus.

Why Python?

Python has a simple, clean syntax. It’s easy to learn.

The type system doesn’t get in the way of coding, if not required.

Python has rich standard libraries and a large amount of powerful additional packages:

- Builtin data types for numbers, strings, lists, tuples, sets, dictionaries
- Strong numeric processing capabilities, with support to fast CPU/GPU parallel processing.
- Large collections of data processing, machine learning tools.
- Good amount of NLP tools.

It’s the fastest growing language among the common used ones.

Which Python version?

3 .5 .6 ...

Which Python version?

Python 3 has been first released in 2008 (3.4 in 2014), it is not a recent novelty.

Python 2 had its last release, 2.7, in 2010, since then it is on end-of-life support.

*“Python 2.x is legacy, **Python 3.x is the present and future of the language**”*

Even if you currently use Python 2.x, do a favor to your future self, **move to Python 3**.

Which Python version?

“But… I use tools that are written in Python 2”

All the major libraries and tools now support Python 3, any Python 2-only package can be considered as not up to date.

Google released its first version of TensorFlow as a Python 2.7 package.

Now TensorFlow on Windows works only with Python 3.5.

Which Python version?

“But… my code is written in Python 2”

Although Python 3 is not fully backward compatible, there are only a few relevant aspects that differ:

- Strings, encodings support (it’s better at supporting non-trivial characters)
- `print`, `except` syntax (it’s more intuitive)
- `irange` → `range` (it’s more efficient)
- Integer division (it’s more intuitive)

Porting Py2 code to Py3 is simple and supported by dedicated tools.

If Instagram has moved its 400M users platform to Py3 you can TRY to move your scripts too.

Installation

Installation

The open source reference implementation of python is available from the python foundation.

However, I strongly suggest you to install the Anaconda distribution.

Anaconda can be installed without super user privileges, and it does not conflicts with existing python installations.

The **conda** management tool for environments and packages is simple to use, and it provides **precompiled** packages for many platforms.

Installation

Once anaconda python is installed, start the ‘Anaconda prompt’ and issue the command:

```
>conda install nb_conda
Fetching package metadata ...........
Solving package specifications: .

Package plan for installation in environment Anaconda3:

The following NEW packages will be INSTALLED:

[..]

Proceed ([y]/n)? y
```

Installation - environments

Environments allow to have multiple, distinct, independent installations of Python, each one with its selection of installed packages:

```
>conda create -n py2 python=2 ipykernel
>conda create -n py3 python=3 ipykernel
```

In this way you can manage a dedicated setup for each of your projects. Messing up one environment does not affects the others.

When you want to use an environment you **activate** it:

```
mac/linux>source activate py3
windows>activate py3
```

Installation

The conda command can be used to install/remove packages:

```
>conda install nltk scikit-learn matplotlib gensim feedparser dill
```

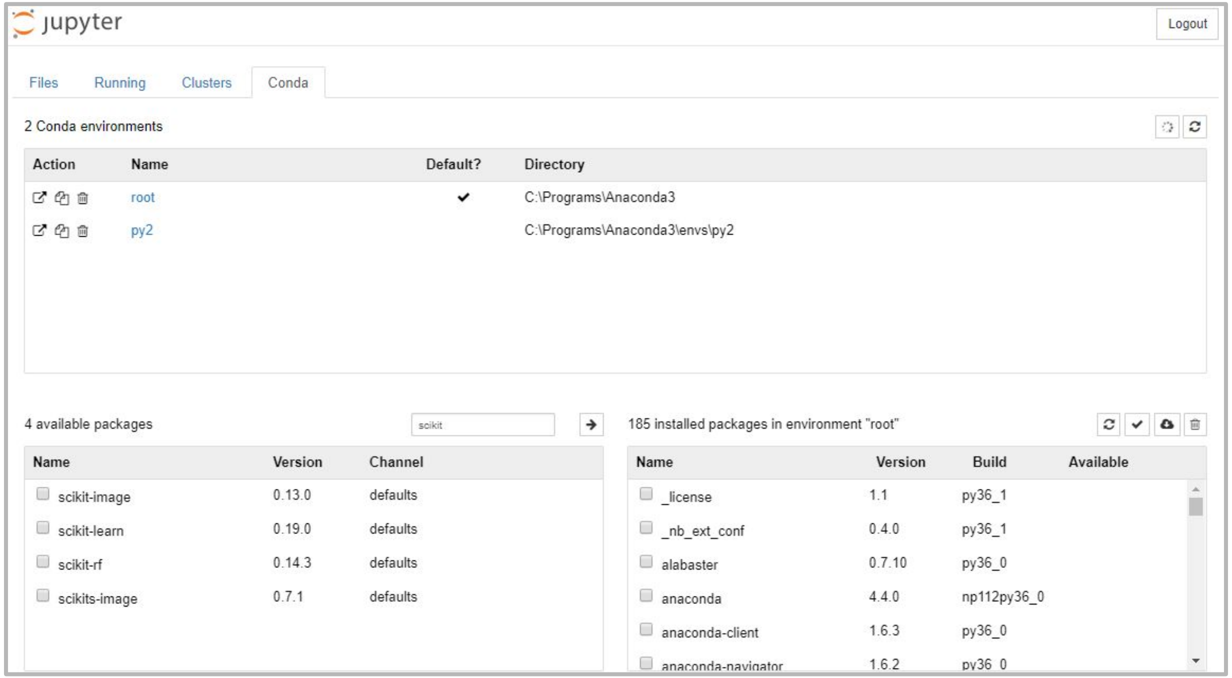
When a package is not available from the anaconda repository, it can be installed using the pip tool, the standard package manager for python:

```
>pip install tweepy
```

Installation

Packages and environments can be managed also from jupyter:

```
From the Anaconda
prompt:

>jupyter notebook
```



2 Conda environments

Action	Name	Default?	Directory
	root	✓	C:\Programs\Anaconda3
	py2		C:\Programs\Anaconda3\envs\py2

4 available packages

Name	Version	Channel
□ scikit-image	0.13.0	defaults
□ scikit-learn	0.19.0	defaults
□ scikit-rf	0.14.3	defaults
□ scikits-image	0.7.1	defaults

185 installed packages in environment "root"

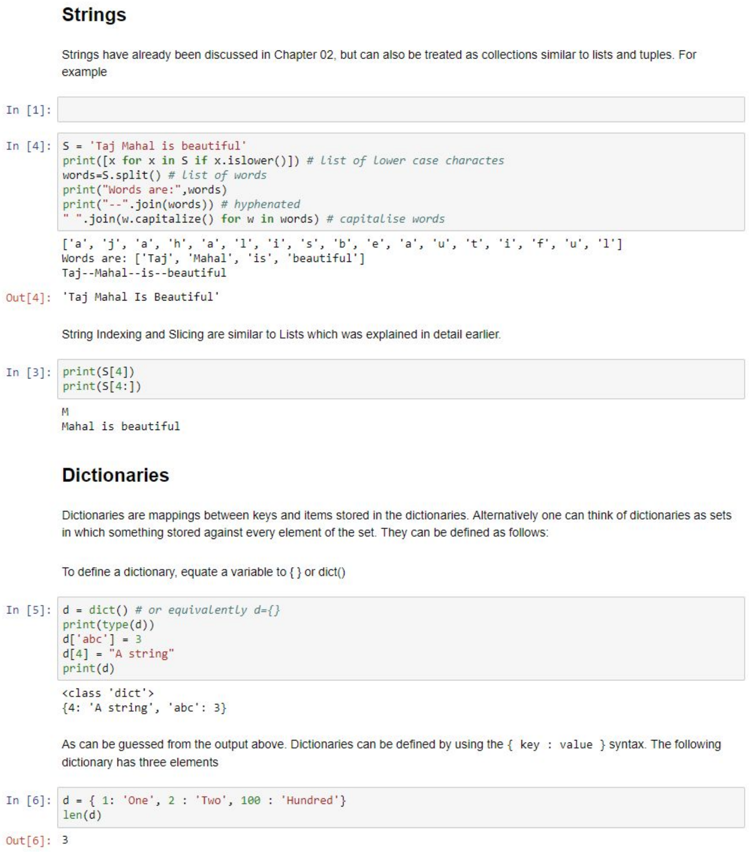
Name	Version	Build	Available
□ _license	1.1	py36_1	
□ _nb_ext_conf	0.4.0	py36_1	
□ alabaster	0.7.10	py36_0	
□ anaconda	4.4.0	np112py36_0	
□ anaconda-client	1.6.3	py36_0	
□ anaconda-navigator	1.6.2	py36_0	

Notebooks

A notebook is an interactive computational environment, in which pieces of code are organized in “code cells” whose output is shown “output cells” the notebook itself.

Notebooks can contain many types of cells, such as rich text, plots, animations.

Notebook are useful for exploration, experimentation, and reporting results.



Strings

Strings have already been discussed in Chapter 02, but can also be treated as collections similar to lists and tuples. For example

```
In [1]:

In [4]: S = 'Taj Mahal is beautiful'
        print([x for x in S if x.islower()]) # List of lower case charactes
        words=S.split() # List of words
        print("Words are:",words)
        print("--".join(words)) # hyphenated
        " ".join(w.capitalize() for w in words) # capitalise words

        ['a', 'j', 'a', 'h', 'a', 'l', 'i', 's', 'b', 'e', 'a', 'u', 't', 'i', 'f', 'u', 'l']
        Words are: ['Taj', 'Mahal', 'is', 'beautiful']
        Taj--Mahal--is--beautiful

Out[4]: 'Taj Mahal Is Beautiful'
```

String Indexing and Slicing are similar to Lists which was explained in detail earlier.

```
In [3]: print(S[4])
        print(S[4:])

        M
        Mahal is beautiful
```

Dictionaries

Dictionaries are mappings between keys and items stored in the dictionaries. Alternatively one can think of dictionaries as sets in which something stored against every element of the set. They can be defined as follows:

To define a dictionary, equate a variable to { } or dict()

```
In [5]: d = dict() # or equivalently d={}
        print(type(d))
        d['abc'] = 3
        d[4] = "A string"
        print(d)

        <class 'dict'>
        {4: 'A string', 'abc': 3}
```

As can be guessed from the output above. Dictionaries can be defined by using the { key : value } syntax. The following dictionary has three elements

```
In [6]: d = { 1: 'One', 2 : 'Two', 100 : 'Hundred'}
        len(d)

Out[6]: 3
```

Scripts

A script is a Python source file, i.e., text file, with .py extension, that defines a directly executable program and/or a module declaring functions and classes.

Content of a hello.py file:

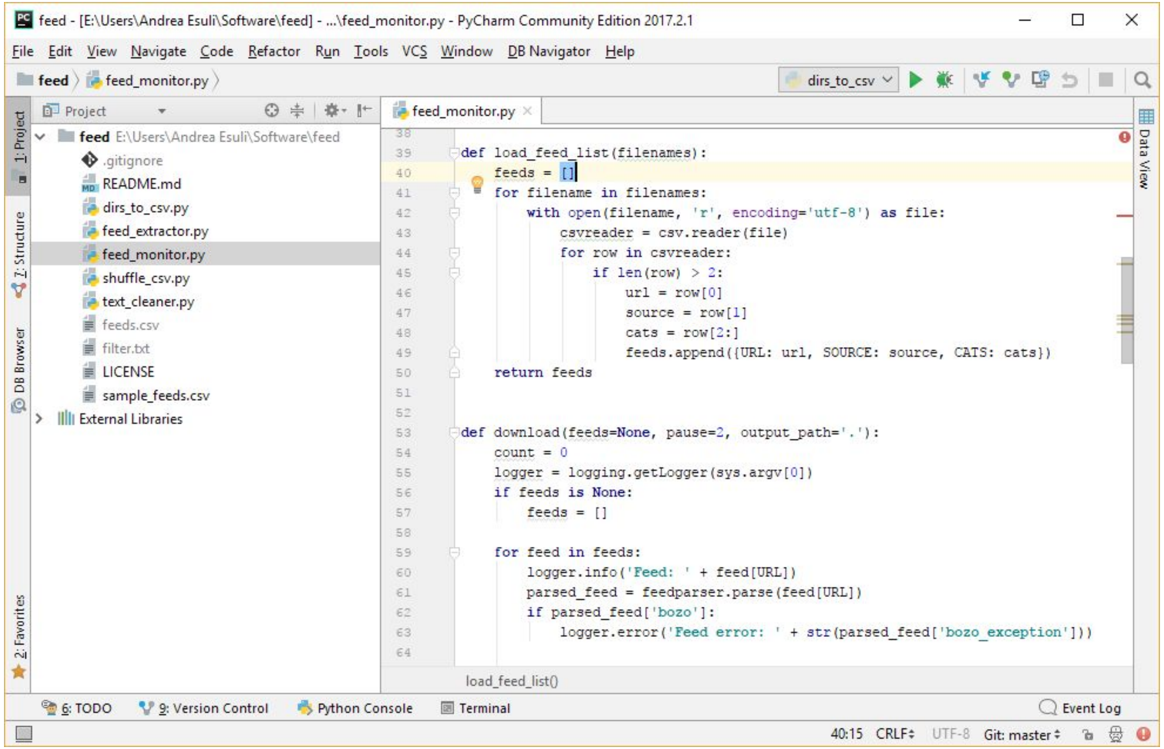
```
def hello():
    print('Hello world!')

hello()
```

Execution:

```
>python hello.py
Hello world!
>
```

Which editor?

I strongly suggest PyCharm.



```python
def load_feed_list(filenames):
    feeds = []
    for filename in filenames:
        with open(filename, 'r', encoding='utf-8') as file:
            csvreader = csv.reader(file)
            for row in csvreader:
                if len(row) > 2:
                    url = row[0]
                    source = row[1]
                    cats = row[2:]
                    feeds.append({URL: url, SOURCE: source, CATS: cats})
    return feeds


def download(feeds=None, pause=2, output_path='.'):
    count = 0
    logger = logging.getLogger(sys.argv[0])
    if feeds is None:
        feeds = []

    for feed in feeds:
        logger.info('Feed: ' + feed[URL])
        parsed_feed = feedparser.parse(feed[URL])
        if parsed_feed['bozo']:
            logger.error('Feed error: ' + str(parsed_feed['bozo_exception']))

```

Basics of Python

Statements

Newlines separates statements.

```
a = 1
b = 2
c = a + b
```

Ending “;” à la C, Java... is OPTIONAL, and almost always **omitted**.

```
a = 1;
b = 2;c = a + b
```

Variables

A variable is a **reference** to an object in memory.

```
a = 1
```

The object of type int “1” is created in some location in memory, a points to that location.

```
b = a
```

b points to the same location of a, thus returns the object “1”

```
b = 2
```

Now b points to the location of a new object int “2”, a still points to “1”

Variables

A variable name is composed of letters, numbers, and the underscore character '_'

- Can't start with a number

```
    1a = 1
    SyntaxError: Invalid syntax
```

- Can use non-ASCII letters in Py3

```
    è_una_variabile = 1
```

- **Cannot** be one of these **reserved words**

```
False class finally is return None continue for lambda try
True def from nonlocal while and del global not with as elif
if or yield assert else import pass break except in raise
```

Variables

A variable is created when it is first assigned to.

```
a = 1
b = a
```

A variable can be deleted.
Deletion removes the name, not the referenced object.

```
del a
b
Out: 1
```

Variables

When an object loses all references it can be **garbage collected**.

```
a = 'hello' # A string object with value ‘hello’
            # is created in memory.
            # Variable ‘a’ points to it.
a = 'world' # Now variable ‘a’ points to this new object.
            # The ‘hello’ object has no references
            # and it is inaccessible, it can be deleted
            # from memory.
```

Python, Java, C#, Javascript use garbage collection. A dedicated process tracks references and deletes inaccessible objects.
C, C++ require the user to explicitly perform memory management.

Variables

The type of a variable changes with the type of the object it references.

```
a = 1
type(a)
Out: int
a = 'ciao'
type(a)
Out: str
a = [1,2,3]
type(a)
Out: list
```

Drawback: type errors are caught only at runtime (yet static typing is possible)

Types

Types

Python interpreter has a number of built-in types:

- NoneType
- Boolean
- Numeric
- Sequences
- Strings
- Sets
- Dictionaries
- Functions
- Classes and methods

None

```
type(None)
NoneType
```

None is the single existing object of type NoneType and it is the equivalent of *null* for many other programming languages.

It is used to indicate the absence of a referred value, **yet the variable exists**.

A common use is to reset a variable, to signal ‘soft’ failures, and in the evaluation of boolean expressions.

Any function that does not explicitly return a value, returns None.

Booleans

Truth values are represented by the bool type:

```
type(True)
Out: bool
```

Constants: `True, False`

Equivalent to `False`: the **None** value, the value **zero** in any numeric type, **empty** sequences, strings, and collections.

Boolean operators: and, or, not

Boolean tests: ==, !=, >, <, in, is

Booleans

Boolean tests: `==, !=, >, <=, >=, <, in, is`

`==` checks for **equivalence of value**, `is` checks for **equivalence of identity**

The `id()` function returns a unique numeric “identity” of any object.

```
a = 'hello '
b = 'world'
c = a + b
d = a + b
c==d, c is d, id(c), id(d)
Out: (True, False, 2287672582000, 2287672579120)
```

Numbers

Three numeric types: int, float, complex.

Integers have unlimited precision (try 9**1000)

bool ⊂ int ⊂ float ⊂ complex

Any operation is done using the "wider" type of the two arguments, if it is defined for the wider type.

Integers can be converted to float only when they are less than:

```
import sys
sys.float_info.max
Out: 1.7976931348623157e+308
```

Numbers

```
x + y       # sum of x and y
x - y       # difference of x and y
x * y       # product of x and y
x / y       # quotient of x and y
x // y      # floored quotient of x and y
x % y       # remainder of x / y
-x          # x negated
abs(x)      # absolute value or magnitude of x
pow(x, y)   # x to the power y
x ** y      # x to the power y
int(x), float(x), complex(x) # explicit number/string conversion
```

Big difference w.r.t. py2: the quotient operation '/' produces a float even when applied on two integers.   Integer quotient operation is '//'.

Numbers

The math module, defines many other mathematical functions.

```
import math
math.factorial(10)
Out: 3628800

math.gcd(234,224)
Out: 1

math.pi
Out: 3.141592653589793
```

For scientific computing numpy is the reference package to use.

Sequence types

Lists

A list is a **mutable** ordered sequence of items of **possibly varied type**.

Note: Ordered ≠ Sorted

Mutable means that the element of the list can be changed *in place*.
The identity of the list does not changes when it is modified.

A list is defined using square brackets, with comma separating items.

```
a = []
a = [ 1, 2, 3]
a = [ 1, 2, 3, 'ciao', [], ['a', 4, None]]
```

Tuples

A tuple is an **immutable** ordered sequence of items of **possibly varied type**.

Immutable means that once defined an object **cannot be modified**.
Operations that “modify” an immutable object **create** in fact **a new object**.

Round brackets define the empty tuple, otherwise **commas define a tuple**, brackets are just a visual clue. Trailing comma is needed only for one-element tuples.

```
a = ()
a = 1,
a = 1, 2, 3
```

Tuples are often used as return value in functions.

Strings

A string is an **immutable** ordered sequence of **Unicode characters**.

A string is defined by using single quotes or double quotes.

```
a = 'this is a test' # or "this is a test" it is the same
```

Triple double quotes define multiline strings.

```
a = """This is a
multiline string"""
Out: 'This is a\nmultiline string'
```

Escape sequences allows to put quotes, newlines, tabs, or other non-trivial chars in strings.

Accessing elements

Elements of a sequence (it is the same for lists, tuples and strings) can be accessed using square bracket index notation.

NOTE: the first element of a sequence has index 0!

```
a = [10, 20, 30]
a[0]
Out: 10
a[1]
Out: 20
len(a) # returns the number of elements in the sequence
Out: 3
len([ 1, 2, 3, 'ciao', [], ['a', 4, None]]) # ???
```

Slicing

Slicing is a powerful tool that allows to **copy** subsequences of a sequence.

```
a[start_idx:end_idx] # copy from start_idx, stop before end_idx
a[start_idx:]    # copy from start_idx through the end of sequence
a[:end_idx]      # copy from beginning, stop before end_idx
a[:]             # copy all the sequence, different from b=a!!!
a[start_idx:end_idx:step] # only pick items every step
```

A **negative index** means it is relative to the end of the sequence.

```
a = [1, 2, 3, 4, 5]
a[:-2]
Out: [1, 2, 3]
```

in

The **in** operator checks for the presence of an item in a sequence.

```
a = [2, 5, 6, 6, 5]
1 in a
Out: False
5 in a
Out True
```

On strings it matches **substrings**.

```
a = 'this is a test'
'a test' in a
Out: True
```

+

The + operator creates **a new sequence** by concatenating its arguments.

```
[1, 2, 3] + [4, 5, 6]
Out:  [1, 2, 3, 4, 5, 6]

(1, 2, 3) + (4, 5, 6)
Out:  (1, 2, 3, 4, 5, 6)

"Hello" + " " + "World"
Out:  'Hello World'
```

*

The * operator creates **a new sequence** by concatenating as many times the sequence argument as expressed by the integer argument.

```
[1] * 9
Out: [1, 1, 1, 1, 1, 1, 1, 1, 1]

[1, [2, 3]] * 3
Out: [1, [2, 3], 1, [2, 3], 1, [2, 3]]

4 * "Hello " + "world" + '!' * 3
Out: 'Hello Hello Hello Hello world!!!'
```

List operations

```
a = [1, 2, 3]
a.append('a')
a
Out: [1, 2, 3, 'a']
```

append adds an element at the end of the list

```
a.insert(2, 'b')
a
Out: [1, 2, 'b', 3, 'a']
```

insert puts the elements in the position specified by the first argument

List operations

```
a = [1, 2, 3]
a.append([4,5,6])
a
Out: [1, 2, 3, [4,5,6]]
```

Use **extend** to copy values for a sequence **into** another.

```
a.extend([4,5,6])
a
Out: [1, 2, 3, 4, 5, 6]
```

```
Note: + creates a new list, does not modify input lists.
```

List operations

```
b = a.pop()
b,a
Out: 'a',[1, 2, 3]
```

pop returns and removes the element at the end of the list.

Use **del** to remove an element given its position:

```
del a[1]
a
Out: [1, 3]
```

remove removes the **first instance** of the given **value**:

```
a.remove(3)
a
Out: [1]
```

List operations

```
a = ['t','e','s','t']
a.index('t')
Out: 0
```

index returns position of the first instance of the given value.

```
a.count('t')
Out: 2
```

count returns the number of instances equivalent (==) to the given value.

List operations

```
a = [2, 1, 5, 4, 3]
a.reverse()
a
Out: [3, 4, 5, 1, 2]
```

reverse the list **in place.**

```
a.sort()
a
Out: [1, 2, 3, 4, 5]
```

sort the list **in place.**

Custom sort can be defined by passing a sorting key function.

Tuple operations

Being immutable, tuples lack most of the functionalities of lists.

Tuples only have **count** and **index** operations.

```
a = (1, 2, 3, 3, 4, 3, 5, 3, 6, 7)
a.count(3)
Out: 4

a.index(3)
Out: 2

a[2]
Out: 3
```

String operations

Strings can be seen as text-specialized tuples.

They offer a number of text-oriented operations.

```
capitalize, encode, format, isalpha, islower, istitle, lower,
replace, rpartition, splitlines, title, casefold, endswith,
format_map, isdecimal, isnumeric, isupper, lstrip, rfind, rsplit,
startswith, translate, center, expandtabs, index, isdigit,
isprintable, join, maketrans, rindex, rstrip, strip, upper, count,
find, isalnum, isidentifier, isspace, ljust, partition, rjust,
split , swapcase, zfill
```

Print, formatting

The **print** function prints values on the screen (or in a file).

Many options of string formatting allow to combine text and values.

```
print('My name is %s and I\'m %d years old' % ('Andrea', 39))
Out: My name is Andrea and I'm 39 years old
```

In python 2 print is a statement that does not require parentheses.

Use the `str()` function to get a string representation of any value.

```
'the list is ' + str([1, 2, 3, 4])
Out: 'the list is [1, 2, 3, 4]'
```

Regular expressions

A regular expression is a search pattern.

Regular expressions are used to find matching patterns in text and to extract relevant substrings from text.

The re module defines objects and methods to apply regular expressions to strings.

Regular expressions are defined as strings that follow a specific syntax.

'[A-Z][a-z]{3}' = *match a sequence of any capital letter followed*
by exactly three lower-case letters, e.g., 'Pisa'

Regular expressions

Basic matching

'a' = character a
'abc' = string abc
'a|b' = match a or b
'a*' = zero or more a
'a+' = one or more a
'a{3}' = exactly 3 a
'a{2,5}' = from 2 to 5 a (the more the better)
'a{2,5}?' = from 2 to 5 a (the less the better)
'a{4,}' = at least 4 a
'a{,3}' = at least 3 a

Regular expressions

Groups

'(abc)' = group, sequence of characters abc

'(abc)+' = one or more time the sequence

'(?P<name>...)' = group named "name"

'(?P=name)' = match the group name

'(?:)' = non capturing (just to define a sequence)

Regular expressions

Characters classes

[abc]	= one in set a,b,c
[a-z0-9]	= one in set of character from a to z and from 0 to 9
[^a-z]	= one character but not those from a to z
\d	= one digit character
\D	= one non-digit character
\s	= one white space character
\S	= one non white space character
\w	= one word character (e.g. a-z A-Z 0-9 _)
\W	= one non-word character

Regular expressions

Other matches

^	= start of string
$	= end of string
\n	= newline
\r	= carriage return
\t	= tab

Start exploring regular expressions here and here.

Regular expressions

Compilation allows efficient reuse of regular expressions, and a clean separation between their definition and their use.

```
tagre = re.compile('<(?P<tag>.+)>(?P<text>.*)</(?P=tag)>')

tagged = tagre.match('<pre>Ciao</pre>')

tagged['tag']
Out: 'pre'

tagged['text']
Out: 'Ciao'
```

Sets and Dictionaries

Sets

A set is an **unsorted** collection of **distinct** (i.e., no duplicates) objects.

```
a = set()
a.add(1)
a.add(2)
a
Out: a = {1, 2}

b = set()
b.add('b')
b.add(3)
a.union(b)
Out: {1, 2, 'b', 3}
```

Dictionaries

Dictionaries define a **mapping** between a set of **keys** and a set of **values**.

Keys must have an immutable type.

Values can have any type.

In a dictionary both keys and values can have mixed types.

```
population = dict() # or population  = {}
population['pisa'] = 91104
population['livorno'] = 160027
population
Out: {'pisa': 91104, 'livorno': 160027}
```

Dictionaries

```
population['pisa']
Out: 91104
```

```
'firenze' in population # check if key exists
Out: False
```

```
population['firenze'] # exception is raised if key does not exist
KeyError: 'firenze'
```

Keys are unique, reassigning replaces value:

```
population['pisa'] = 10000000
population['pisa']
Out: 10000000
```

Dictionaries

```
del population['livorno']
population['livorno']
KeyError: 'livorno'
```

Empty a dictionary with **clear** (also works on sets and lists):

```
population.clear()
population
Out: {}
```

Dictionaries

```
ages = {'Andrea': 39, 'Giuseppe': 67, 'Paolo': 58}
ages.keys()
Out: dict_keys(['Andrea', 'Giuseppe', 'Paolo'])

ages.values()
Out: dict_values([39, 67, 58])

ages.items()
Out: dict_items([('Andrea', 39), ('Giuseppe', 67), ('Paolo', 58)])
```

`dict_keys`, `dict_values`, `dict_items` are **mutable views** of the dictionary, i.e., they change as the dictionary changes.
They are **iterables**.