

# Introduction to Python: Data types

HORT 59000

Lecture 8

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# Why Python?

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- Readability and ease-of-maintenance
  - Python focuses on well-structured easy to read code
  - Easier to understand source code...
  - ..hence easier to maintain code base
- Portability
  - Scripting language hence easily portable
  - Python interpreter is supported on most modern OS's
- Extensibility with libraries
  - Large base of third-party libraries that greatly extend functionality. Eg., NumPy, SciPy etc.

# Python Interpreter

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- The system component of Python is the interpreter.
- The interpreter is independent of your code and is required to execute your code.
- Two major versions of interpreter are currently available:
  - Python 2.7.X (discontinued 2020, legacy libraries)
  - Python 3.9.X (newer features, better support)

# Python execution model

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- Source code is compiled into byte code
- Byte code is executed on the Python Virtual Machine
- Byte code is regenerated every time source code OR the python version on the machine changes.
- Byte code generation saves repeated compilation time.

# Script vs. command line

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- Code can be written in a python script that is interpreted as a block.
- Code can also be entered into the Python command line interface.
  - You can exit the command line with Ctrl-z on windows and Ctrl-d on unix
- For complex projects use an IDE (For example, PyCharm, Jupyter notebook).
  - PyCharm is great for single-developer projects
  - Jupyter is great sharing code and output with markup

# First script

```
kvarala@scholar-fe00:~ $ python
Python 2.7.5 (default, Apr  2 2020, 13:16:51)
[GCC 4.8.5 20150623 (Red Hat 4.8.5-39)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> print('hello world!')
hello world!
>>> █
```

- This is the command line interface
- Simply type in the command and the output, if any, is returned to the screen.
- May also be written as a script:

```
kvarala@scholar-fe00:~/scratch/scholar/kvarala/ICB/Week8 $ cat hello.py
#!/usr/bin/python
print('hello world!')
kvarala@scholar-fe00:~/scratch/scholar/kvarala/ICB/Week8 $ python hello.py
hello world!
kvarala@scholar-fe00:~/scratch/scholar/kvarala/ICB/Week8 $ █
```

# Variables and Objects

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- Variables are the basic unit of storage for a program.
- Programs perform operations on variables and alter or fill in their values.
- Objects are higher level constructs that include one or more variables and the set of operations that work on these variables.

# Classes vs. Objects

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- Every Object belongs to a certain class.
- Classes are abstract descriptions of the structure and functions of an object.
- Objects are created when an instance of the class is created by the program.
- For example, "Fruit" is a class while an "Apple" is an object.



# What is an Object?

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- Almost everything is an object in Python, and it belongs to a certain class.
- Python is dynamically and strongly typed:
  - Dynamic: Objects are created dynamically when they are initiated and assigned to a class.
  - Strong: Operations on objects are limited by the type of the object.
- Every variable you create is either a built-in data type object OR a new class you created.

# Core data types (class)

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- Numbers
- Strings
- Lists
- Dictionaries
- Tuples
- Files
- Sets

# Numbers

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- Can be integers, decimals (fixed precision), floating points (variable precision), complex numbers etc.
- Simple assignment creates an object of number type such as:
  - $a = 3$
  - $b = 4.56$
- Supports simple to complex arithmetic operators.
- Assignment via numeric operator also creates a number object:
  - $c = a / b$
- $a$ ,  $b$  and  $c$  are numeric objects.
- Try `dir(a)` and `dir(b)` . This command lists the functions available for these objects.

# Strings

- A string object is a 'sequence', i.e., it's a list of items where each item has a defined position.
- Each character in the string can be referred, retrieved and modified by using its position.
- This order id called the 'index' and always starts with 0.

```
>>> S = 'Hello'
>>> len(S)
5
>>> S[0]
'H'
>>> S[4]
'o'
>>> S[5]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: string index out of range
```

```
>>> S[-1]
'o'
>>> S[3:]
'lo'
>>> S[2:5]
'llo'
```

# Strings ... continued

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- String objects support concatenation and repetition operations.

```
>>> S + 'World!'
'HelloWorld!'
>>> S + ' World!'
'Hello World!'
>>> S * 4
'HelloHelloHelloHello'
>>> S + ' World! ' * 4
'Hello World! World! World! World! '
>>> (S + ' World! ') * 4
'Hello World! Hello World! Hello World! Hello World! '
```

# Lists

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- List is a more general sequence object that allows the individual items to be of different types.
- Lists have no fixed size and can be expanded or contracted as needed.
- Items in list can be retrieved using the index.
- Lists can be nested i.e., you can have a list of lists.

# Lists

- Simple list:

```
>>> L = [123, 3.14, 'Hello']
>>> L
[123, 3.1400000000000001, 'Hello']
```

```
>>> L[0]
123
```

- Nested list:

```
>>> DDL = [[1,2,3],
... [4,5,6],
... [7,8,9]]
>>> DDL
[[1, 2, 3], [4, 5, 6], [7, 8, 9]]
```

```
>>> DDL[2][1]
8
```

# Dictionaries

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- Dictionaries are unordered mappings of 'Name : Value' associations.
- Intended to approximate how humans remember associations.

```
>>> D = {'name': 'apple', 'color': 'red', 'taste': 'sweet', 'number': '5'}
>>> D['name']
'apple'
>>> D
{'color': 'red', 'taste': 'sweet', 'name': 'apple', 'number': '5'}
```



# Files

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- File objects are built for interacting with files on the system.
- Same object used for any file type.
- User has to interpret file content and maintain integrity.

```
>>> f = open('test.txt', 'w')
>>> f.write('Hello\t')
>>> f.write('world!\n')
>>> f.close()
>>> f = open('test.txt')
>>> text = f.read()
>>> text
'Hello\tworld!\n'
>>> print(text)
Hello    world!
```

# Mutable vs. Immutable

- Numbers, strings and tuples are immutable i.,e cannot be directly changed.
- Lists, dictionaries and sets can be changed in place.

```
>>> S[0]
'H'
>>> S[0] = 'h'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'str' object does not support item assignment
>>> L[1] ← Object from Slide 15
3.1400000000000001
>>> L[1] = 3.145
```

# Tuples

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- Tuples are immutable lists.
- Maintain integrity of data during program execution.
- For example,
  - input data from the user that **SHOULD NOT** be modified until the end of the program.
  - Local (in memory) copy of a database.

# Sets

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- Special data type introduced since Python 2.4 onwards to support mathematical set theory operations.
- Unordered collection of *unique* items.
- Set itself is mutable, BUT every item in the set has to be an immutable type.
- So, sets can have numbers, strings and tuples as items but cannot have lists or dictionaries as items.

# Summary

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- Python interpreter executes byte code which is generated from your source code.
- Variables in Python are objects that are in turn instances of a pre-defined class.
- Variables are dynamically and strongly typed.
- Python supports a set of core data types (i.e., classes).
- Numbers, strings and tuples are immutable data types, while lists, dictionaries and sets are mutable datatypes.