02 – Basic scalar data types

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Data types

Immutable data types

- Can not be changed once they have been created
- You must create a new (changed) instance if you want to change them
- Examples: bool (True, False), integer, float, string, tuple, frozen set, etc.

Mutable data types

- Their content can be changed after their creation
- Examples: list, set, dictionary, file, etc.
- Handling of mutable data types can have certain “**side-effects**”

Integers (int)

- Range: arbitrary
- If value is beyond the long int data type in C (2**63 on 64 bit machines), operations become rather slow (runs emulated, not natively)

Runs the cell a given amount of time and measures execution time

% Jupyter kernel “magic” commands

```
%%timeit -r 10
num = 2**3625
for ii in range(63):
    num *= 2
```

Compare

```
%%timeit -r 10
num = 2**0
for ii in range(63):
    num *= 2
```

Floating point numbers (float, complex)

Real numbers

- The same as double type in C
  - Range: +/-1E-323 – +/-1E+308
  - Precision: 16 digits
- Can be entered either in fixed or in expontential notation

```
>>> 0.123
0.123
>>> 1.23E-1
0.123
>>> 9e-1300
0
>>> 9e1000
inf
```

Complex numbers

- Represented by a pair of real numbers
- Real and imaginary part have the same range then usual real numbers
- Input as ***RealPart + ImaginaryPartJ***

```
>>> 2.0 + 3.3j
(2+3.3j)
```

Arithmetic operators

`+`	Addition
`-`	Substraction
`*`	Multiplication
`/`	Division
`//`	Integer division
`%`	Division remainder
`-`	Negation
`**`	Power

```
>>> 1 + 2
3
>>> 3 - 4
-1
>>> 5 * 6
30
>>> 5 / 2
2.5
```

```
>>> 5 // 2
2
>>> 5 % 2
1
>>> -8
-8
>>> 2**0.5
1.4142135623730951
```

Relation operators

```
==    equal
!=    unequal
<     less
<=    less equal
>     greater
>=    greater equal
```

```
>>> 3 == 2
False
>>> 3 != 2
True
>>> 3 < 2
False
>>> 3 > 2
True
>>> 3 >= 2
True
>>> 3 <= 2
False
```

Comparison gives bool type as result (True/False)

```
>>> 3.0+2j == 3.0+3j
False
>>> 3.0+2j != 3.0+3j
True
>>> 3.0+2j < 2.0-1.2j
Traceback (most recent call...
```

Error: Complex numbers can not be ordered

Comparing with == or != is OK

Booleans (bool) & logical operators

- They are actually numbers, only shown differently
  - **False**: 0, **True**: 1

```
>>> True
True
>>> False
False
>>> 2 * True
2
```

Logical operators

- Logical **AND** (True if both operands True)
- Logical **OR** (True if any of the operands True)
- Logical **NOT** (Negates operand)

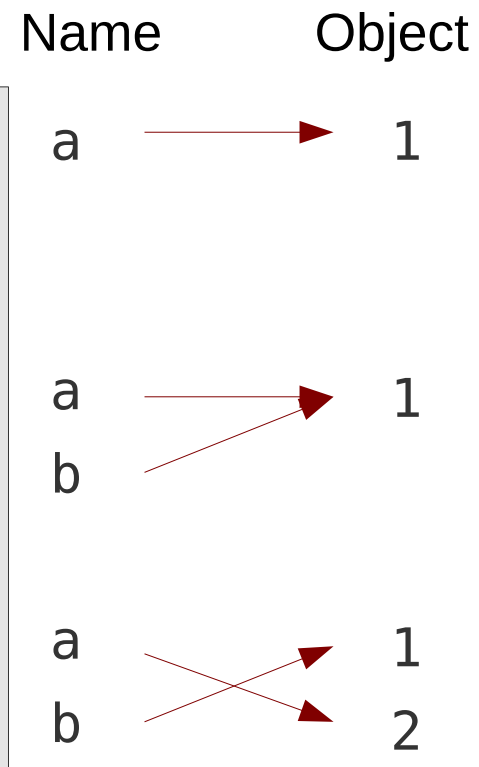
```
>>> True and False
False
>>> False or True
True
>>> not True
False
```

- In Python each object can serve as a logical value (details later)

Assignment

- An object (e.g. result of an operation) gets a name assigned (variable name)
- **Name = Objec**t
  Name points to / aliases Object
- **Name1 = Name2**
  Name1 points to the same object which Name2 points to
- When using a variable name in an expresssion, it will be substituted with the object it points to.
- There are **no “classic” variables** in Python, just **pointers / aliases**!

```
>>> a = 1
>>> a
1
>>> b = a
>>> b
1
>>> a = 2
>>> a
2
>>> b
1
>>> a + b
3
```



Strings

- Strings are specified between apostrophes or quotes:

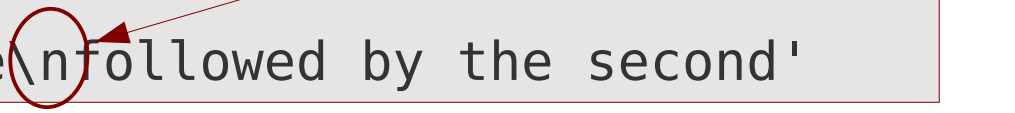
```
>>> name1 = 'john'
>>> name2 = "tom"
>>> name1
'john'
>>> name2
'tom'
```

- Length of a string can be queried by the **len()** function:

```
>>> len(name1)
4
```

- Multilne strings can be specified between triple apostrophes or quotes:

```
>>> longstr = """First line
... followed by the second"""
>>> longstr
'First line\nfollowed by the second'
```



Strings

- Parts of a string can be accessed by the **[]** operator:

Elements are enumerated **starting with zero**

When selecting ranges as **[lower:upper]**, the **lower bound** is **inclusive** the **upper bound** is **exclusive**

Range increment can be also specified with **[lower:upper:increment]**

When lower bound is omitted, range starts from the very first element (0 – range increment pos., last – range increment neg.)

When upper bound is omitted, range ends beyond last element (last element is included)

Negative range increment: iterating backwards

Empty range returns empty string

```
>>> txt = "some text"
>>> txt[0]
's'
>>> txt[0:4]
'some'
>>> txt[0:9:2]
'sm et'
>>> txt[:4]
'some'
>>> txt[4:]
' text'
>>> txt[8:4:-1]
'txet'
>>> txt[3:3]
''
```

Strings

- Strings are immutable, they can not be changed once created:

```
>>> txt[0] = 'b'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'str'...does not support item assignment
```

- Strings can be **concatenated** by the **+ operator** or by whitespace for string literals:

```
>>> name1 + " " + name2
'john tom'
>>> "str1" "str2"
'str1str2'
```

- Strings can be **repeated** by the *** operator**:

```
>>> "ab" * 3
'abababab'
```

String formatting, f-strings

- Formatted strings (**f-strings**): String scontaining expressions with optional formatting options
- Expressions are enclosed in {}

```
aa = 12
bb = 135
print(f"a = {aa}, b = {bb}")
```

```
a = 12, b = 135
```

- Optional formatting options can be specified after the expression, separated by a colon (**:**)

```
print(f"a = {aa:3d}\nb = {bb:3d}")
```

Newline character Field width Data type

```
a =  12
b = 135
```

- Data type must match expression type:

```
cc = 12.35
print(f"c = {cc:4d}")
```

```
ValueError: Unknown format code 'd'
for object of type 'float'
```

Few formatting options

:*W*d	integer number
:*W*.*P*f	floating point number in fixed notation
:*W*.*P*e	floating point number in exponential notation (with small e)
:*W*.*P*E	floating point number in exponential notation (with capital E)
:*W*.*P*g	:f or :e depending on the value of the floating point
:*W*.*P*G	:f or :e depending on the value of the floating point
:W*s*	string (converts given object to a string)

W (width) minimal field width (optional) *P* (precision) number of decimal places (optional)

```
ff = 1.2
f"{ff:12.4E}"
f"{ff:12E}"
f"{ff:.4E}"
ss = "ab"
f"{ss:5s}"
```

```
'  1.2000E+00'
'1.200000E+00'
'1.2000E+00'

'ab   '
```

Numbers aligned right

String aligned left

For further formatting options see the format specification mini-language

Few remarks on string formatting

- If the field with is too small for the given represenation, it will be automatically expanded

```
num = 123
f"|{num:1d}|"  →  '|123|'
```

- If you need literal curly braces in the formatted string, they must be doubled:

```
num = 123
f"{{{0:d}}}"  →  '{123}'
```

- Formatted strings can be created with the **.format()** method as well
- Expressions are given as parameters of the **.format()** method

```
num = 123
"|{:4d}|".format(num)  →  '| 123|'
```

- Parameters can be refered by their position

```
num1 = 12
num2 = 34
"|{0:d}, {1:d}, {0:d}|".format(num1, num2)
      0       1
'|12, 34, 12|'
```

Converting data types into each other

- Each data type has a special function, which tries to convert its argument into an object with the given data type:

```
int(), float(), complex(), str()
```

- Argument can have arbitrary data type
- If the conversion fails, an exception is raised (error)

```
>>> int(3.2)
3
>>> float("12.1")
12.1
>>> complex("3+2j")
(3+2j)
>>> complex("3.0+2.0j")
(3+2j)
```

```
>>> valstr = "3"
>>> int(valstr)
3
>>> int("hello")
Traceback ...ValueError: ...
```