Python basics

- Comments
- ";"
- Variable names
- int, float, str
- type conversion
- assignment (=)
- print(), help(), type()

Python comments

A ‘#’ indicates the beginning of a comment. From ‘#’ until of end of line is ignored by Python.

```
x = 42  # and here goes the comment
```

Comments useful to describe what a piece of code is supposed to do, what kind of input is expected, what is the output, side effects...

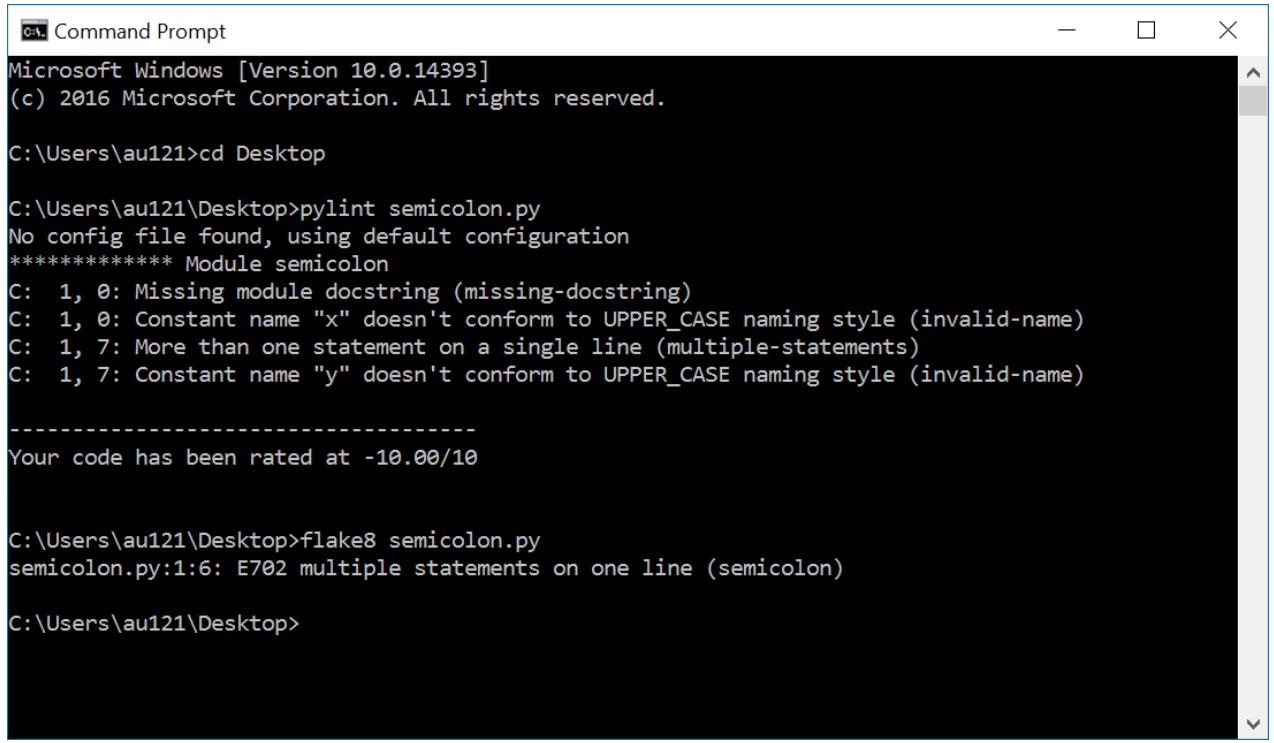
The “;” in Python

- Normally statements follow in consecutive lines with identical indentation

```
x = 1
y = 1
```

- but Python also allows multiple statements on one line, separated by “;”

```
x = 1; y = 1
```



neither **pylint** or **flake8** like “;”

- General Python PEP 8 guideline: **avoid using “;”**
- Other languages like C, C++ and Java require “;” to end/separate statements

Variable names

- Variable name = sequence of **letters** ‘a’-’z’, ‘A’-’Z’, **digits** ‘0’-’9’, and **underscore** ‘_’

```
v, volume, height_of_box, WidthOfBox, x0, _v12_34B, _
```

(snake_case) (CamelCase)

  - a name cannot start with a digit
  - names are case sensitive (`AB`, `Ab`, `aB` and `ab` are different variables)

- Variable names are references to objects in memory
- **Use meaningful variables names**
- **Python 3 reserved keywords:** `and`, `as`, `assert`, `break`, `class`, `continue`, `def`, `del`, `elif`, `else`, `except`, `False`, `finally`, `for`, `from`, `global`, `if`, `import`, `in`, `is`, `lambda`, `nonlocal`, `None`, `not`, `or`, `pass`, `raise`, `return`, `True`, `try`, `while`, `with`, `yield`

Question – Not a valid Pyton variable name?

a) `print`

b) `for` Python reserved keyword

c) `_100`

d) `x`

e) `_`

f) `python_for_ever`

g) Don’t know

Python shell

```
> print = 7
> print(42)
| Traceback (most recent call last):
|   File "<stdin>", line 1, in <module>
| TypeError: 'int' object is not callable
```

`print` is a valid variable name, with default value a builtin *function* to print output to a shell – assigning a new value to `print` is very likely a bad idea (like many others `sum`, `int`, `str`, ...)

Integer literals

- …. `-4, -3, -2, -1, 0, 1, 2, 3, 4` ….
- Python integers can have an arbitrary number of digits (only limited by machine memory)
- Can be preceded by a plus `(+)` or minus (−)
- For readability underscores (_) can be added between digits,

```
2_147_483_647
```

(for more, see PEP 515 - Underscores in Numeric Literals)

Question – What statement will not fail?

a) `x = _42`

b) `_10 = -1_1`

c) `x = 1__0`

d) `x = +1_0_`

e) Don’t know

Float literals

- Decimal numbers are represented using **float** – contain "." or "e"
- Examples
  - `3.1415`
  - `-.00134`
  - `124e3` = $124 \cdot 10^3$
  - `-2.345e2` = `-234.5`
  - `12.3e-4` = `0.00123`
- ⚠ Floats are often only approximations, e.g. `0.1` is *not* 1/10
- Extreme values (CPython)
  - max = 1.7976931348623157e+308
  - min = 2.2250738585072014e-308
- NB: Use module `fractions` for exact fractions/rational numbers.

Python shell

```
> 0.1 + 0.2 + 0.3
| 0.6000000000000001
> (0.1 + 0.2) + 0.3
| 0.6000000000000001
> 0.1 + (0.2 + 0.3)
| 0.6
> type(0.1)
| <class 'float'>
> 1e200 * 1e300
| inf
> 0.1+(0.2+0.3) == (0.1+0.2)+0.3
| False
> x = 0.1 + 0.2
> y = 0.3
> x == y
| False
> print(f'{x:.30f}')  # 30 decimals
| 0.300000000000000044408920985006
> print(f'{y:.30f}')  # 30 decimals
| 0.299999999999999988897769753748
> import sys
> sys.float_info.min
| 2.2250738585072014e-308
> sys.float_info.max
| 1.7976931348623157e+308
```

Associativity rule does not apply to floats

Question – What addition order is ”best”?

a) `1e10 + 1e-10 + -5e-12 + -1e10`

b) `1e10 + -1e10 + 1e-10 + -5e-12`

c) `1e-10 + 1e10 + -1e10 + -5e-12`

d) `-5e-12 + -1e10 + 1e10 + 1e-10`

e) Any order is equally good

f) Don’t know

```
 1e10  =  10000000000
-1e10  = -10000000000
 1e-10 =             0.0000000001
-5e-12 =            -0.000000000005
```

Python shell

```
> 1e10 + 1e-10 + -5e-12 + -1e10
| 0.0
> 1e10 + -1e10 + 1e-10 + -5e-12
| 9.500000000000001e-11
> 1e-10 + 1e10 + -1e10 + -5e-12
|  -5e-12
> -5e-12 + -1e10 + 1e10 + 1e-10
|  1e-10
```

a) - d) give four different outputs

Approximating π = 3.14159265359...

$$\frac{\pi^2}{6} = \sum_{k=1}^{+\infty} \frac{1}{k^2} = \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \cdots$$

$$= 1.6449340668...$$

Riemann zeta function ζ(2)

pi_approximation_riemann.py

```
apx = 0.0
k = 0.0
while True:
    k = k + 1.0
    apx = apx + 1.0 / (k * k)
    print(k, apx)
```

Output

```
...
94906261.0 1.6449340578345741
94906262.0 1.6449340578345744
94906263.0 1.6449340578345746
94906264.0 1.6449340578345748
94906265.0 1.644934057834575
94906266.0 1.644934057834575
94906267.0 1.644934057834575
94906268.0 1.644934057834575
94906269.0 1.644934057834575
94906270.0 1.644934057834575
...
```

This is not a course in numeric computations – but now you are warned....

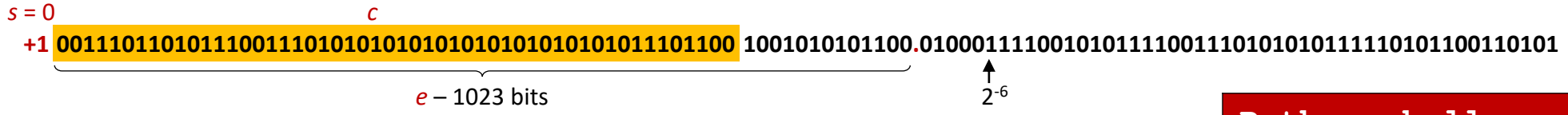
Python float ≡ IEEE-754 double precision*

- A binary number is a number in base 2 with digits/bits from {0,1}

$$10110_2 = 1\cdot2^4 + 0\cdot2^3 + 1\cdot2^2 + 1\cdot2^1 + 0\cdot2^0 = 16 + 4 + 2 = 22_{10}$$

- IEEE-754 64-bit double

sign *s* 1 bit	exponent *e* 11 bits	coefficient *c* 52 bits



Float value	Case
$(-1)^s \cdot (1 + c \cdot 2^{-52}) \cdot 2^{e-1023}$	$0 < e < 2047$
$(-1)^s \cdot c \cdot 2^{-1074}$	$e = 0, c \neq 0$
+0 and -0	$e = 0, c = 0$
+∞ and -∞	$e = 2047, c = 0$
NaN (“not a number”)	$s = 0, e = 2047, c \neq 0$

Python shell

```
> 1e200 * 1e200
| inf
> -1e200 * 1e200
| -inf
> 1e-200 * 1e-200
| 0.0
> -1e-200 * 1e-200
| -0.0
> 1e200 * 1e200 * 0.0
| nan
```

(*most often, but there is no guarantee given in the Python language specification that floats are represented using IEEE-754)

String literals (type `str`)

- Sequence of characters enclosed by single (') or double (") quotes

```
"a 'quoted' word"    "Hello World"    'abc'
'a "quoted" word'    '_"_\'_"_'
```

- Escape characters

`\n`	newline
`\t`	tab
`\\`	backslash
`\'`	single quote
`\"`	double quote

- A backslash (\) a the end of line, will continue line/string on next line
- Use triple single or double quotes (''' or """) for enclosing strings spanning more lines

  (in particular for Python Dosctrings, see PEP 257)

string-test.py

```
print("abc")
print('de\'f')
print("'ghi'")
print("'jk\nl'\"")
print("mn\
o")
print("p\\q\tr")
```

Output

```
$ python string-test.py
abc
de'f
'ghi'
'jk
l'"
mno
p\q     r
```

Question – What does the following print ?

```
print("\\\"\\n\n'")
```

a) `\\\"\\n\n'`

b) `\"\nn'`

c) `\"\n`
`'`

d) `"nn'`

e) `\"`

`'`

f) Don’t know

Long string literals

- Long string literals often need to be split over multiple lines
- In Python two (or more) string literals following each other will be treated as a single string literal (they can use different quotes)
- Putting parenthesis around multiple literals allows line breaks
- Advantages:
  - avoids the backslash at the end of line
  - can use indentation to increase readability
  - allows comments between literals

long-string-literals.py

```
s1 = 'abc' "def"  # two string literals
print(s1)
s2 = '"' "'" '"'  # avoid escaping quotes
print(s2)
s3 = 'this is a really, really, really, \
really, really, long string'
print(s3)
s4 = ('this is a really, really, '
      'really, really, really, '
      'long string')
print(s4)
very_very_long_variable_name = (
    'this is a really, really, '  # line 1
    'really, really, really, '    # line 2
    "long string"                 # line 3
)
print(very_very_long_variable_name)
```

Python shell

```
abcdef
"'"
this is a really, really, really, really,
really, long string
this is a really, really, really, really,
really, long string
this is a really, really, really, realy,
really, long string
```

Raw string literals

- By prefixing a string literal with an `r`, the string literal will be considered a raw string and backslashes become literal characters
- Useful in cases where you actually need backslashes in your strings, e.g. when working with Python's regular expression module `re`

Python shell

```
> print('\let\epsilon\varepsilon')      # \v = vertical tab
| \let\epsilon
  arepsilon
> print('\\let\\epsilon\\varepsilon')   # many backslashs
| \let\epsilon\varepsilon
> print(r'\let\epsilon\varepsilon')     # more readable
| \let\epsilon\varepsilon
```

print(...)

- `print` can print zero, one, or more values
- default behavior
  - print a space between values
  - print a line break after printing all values
- default behavior can be changed by **keyword arguments** "`sep`" and "`end`"

Python shell

```
> print()
|
> print(7)
| 7
> print(2, 'Hello')
| 2 Hello
> print(3, 'a', 4)
| 3 a 4
> print(3, 'a', 4, sep=':')
| 3:a:4
> print(5); print(6)
| 5
| 6
> print(5, end=', '); print(6)
| 5, 6
```

print(...) and help(...)

Python shell

```
> help(print)
| Help on built-in function print in module builtins:
|
| print(...)
|     print(value, ..., sep=' ', end='\n', file=sys.stdout, flush=False)
|
|     Prints the values to a stream, or to sys.stdout by default.
|     Optional keyword arguments:
|     file:  a file-like object (stream); defaults to the current sys.stdout.
|     sep:   string inserted between values, default a space.
|     end:   string appended after the last value, default a newline.
|     flush: whether to forcibly flush the stream.
```

Assignments

- *variable* = *expression*

```
x = 42
```

- Multiple assignments – right hand side evaluated before assignment

```
x, y, z = 2, 5, 7
```

- Useful for swapping

```
x, y = y, x
```

- Assigning multiple variables same value in left-to-right

```
x = y = z = 7
```

Warning

```
i = 1
i = v[i] = 3  # v[3] is assigned value 3
```

In languages like C and C++ instead
v[1] is assigned 3

Python is dynamically typed, type(…)

- The current type of a value can be inspected using the **type()** function (that returns a type object)
- In Python the values contained in a variable over time can be of different type
- In languages like C, C++ and Java variables are declared with a given type, e.g.

```
int x = 42;
```

and the different values stored in this variable must remain of this type

Python shell

```
> x = 1
> type(x)
| <class 'int'>
> x = 'Hello'
> type(x)
| <class 'str'>
> type(42)
| <class 'int'>
> type(type(42))
| <class 'type'>
```

Type conversion

- Convert a value to another type:

  new-type(*value*)

- Sometimes done automatically:

```
1.0+7=1.0+float(7)=8.0
```

Python shell

```
> float(42)
| 42.0
> int(7.8)
| 7
> x = 7
> print("x = " + x)
| Traceback (most recent call last):
|   File "<stdin>", line 1, in <module>
| TypeError: must be str, not int
> print("x = " + str(x))
| x = 7
> print("x = " + str(float(x)))
| x = 7.0
> int("7.3")
| Traceback (most recent call last):
|   File "<stdin>", line 1, in <module>
| ValueError: invalid literal for int() with base 10: '7.3'
> int(float("7.3"))
| 7
```

Questions – `str(float(int(float("7.5"))))` ?

a) 7

b) 7.0

c) 7.5

d) "7"

 e) "7.0"

f) "7.5"

g) Don’t know