

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 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...

Comments are aimed at people (including yourself) reading the code

The “;” in Python

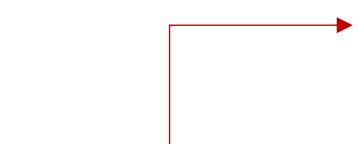
- Normally statements follow in consecutive lines with identical indentation

```
x = 1
```

```
y = 1
```

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

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



```
Command Prompt
Microsoft Windows [Version 10.0.14393]
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C:\Users\au121>cd Desktop

C:\Users\au121\Desktop>pylint semicolon.py
No config file found, using default configuration
*****
Module semicolon
C: 1, 0: Missing module docstring (missing-docstring)
C: 1, 0: Constant name "x" doesn't conform to UPPER_CASE naming style (invalid-name)
C: 1, 7: More than one statement on a single line (multiple-statements)
C: 1, 7: Constant name "y" doesn't conform to UPPER_CASE naming style (invalid-name)

-----
Your code has been rated at -10.00/10

C:\Users\au121\Desktop>flake8 semicolon.py
semicolon.py:1:6: E702 multiple statements on one line (semicolon)

C:\Users\au121\Desktop>
```

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

Question – Not a valid Python variable name?

- a) print
- b) for
- c) _100
- d) x
- e) _
- f) python_for_ever
- g) Don't know



Python reserved keyword

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 (-)
- Leading zeros are not allowed (e.g., 7 cannot be written as 007)
- For readability underscores (_) can be added between digits,

2 _ 1 4 7 _ 4 8 3 _ 6 4 7

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

Question – What statement will not fail?

- a) $x = -42$
- b) $-10 = -1_1$
- c) $x = 1_\underline{0}$
- d) $x = +1\underline{\underline{0}}$
- e) Don't know

Float literals

- Decimal numbers are represented using **float** – contain “.” or “e”
- Examples
 - 3.1415
 - -.00134
 - $124\text{e}3 = 124 \cdot 10^3$
 - $-2.345\text{e}2 = -234.5$
 - $12.3\text{e}-4 = 0.00123$
-  Floats are often only approximations, e.g. 0.1 is *not* $1/10$
- Extreme values (CPython)
 - $\text{max} = 1.7976931348623157\text{e}+308$
 - $\text{min} = 2.2250738585072014\text{e}-308$
- 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
| 0.29999999999999988897769753748
> 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

| | |
|------------|-----------------|
| $1e10 =$ | 1000000000 |
| $-1e10 =$ | -1000000000 |
| $1e-10 =$ | 0.0000000001 |
| $-5e-12 =$ | -0.000000000005 |

Approximating $\pi = 3.14159265359\dots$

$$\frac{\pi^2}{6} = \sum_{k=1}^{+\infty} \frac{1}{k^2} = \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \dots$$
$$= 1.6449340668\dots$$

Riemann zeta function $\zeta(2)$

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 \equiv IEEE-754 double precision*

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

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

- IEEE-754 64-bit double

| sign s 1 bit | exponent e 11 bits | coefficient c 52 bits |
|-------------------|-------------------------|----------------------------|
|-------------------|-------------------------|----------------------------|

$s = 0$ c
 $+1$ 

| 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 | $e = 0, c = 0$ |
| $\pm\infty$ and $-\infty$ | $e = 2047, c = 0$ |
| 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 |
| \N{ <i>unicode name</i> } | |

- A backslash (\) at 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 Docstrings, see [PEP 257](#))

string-test.py

```
print("abc")  
print('de\f')  
print("ghi")  
print('''jk\nl''')  
print("mn\  
o")  
print("p\q\t")  
print("\N{SNOWMAN}")
```

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, really,
| 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
\varepsilon
> print('\\let\\epsilon\\varepsilon')  # many backslashes
| \let\epsilon\varepsilon
> print(r'\let\epsilon\varepsilon')    # more readable
| \let\epsilon\varepsilon
```

- Strange exception: A raw string cannot end with an odd number of backslashes

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

- $\text{variable} = \text{expression}$

`x = 42`

- Multiple assignments – right hand side evaluated before assignment

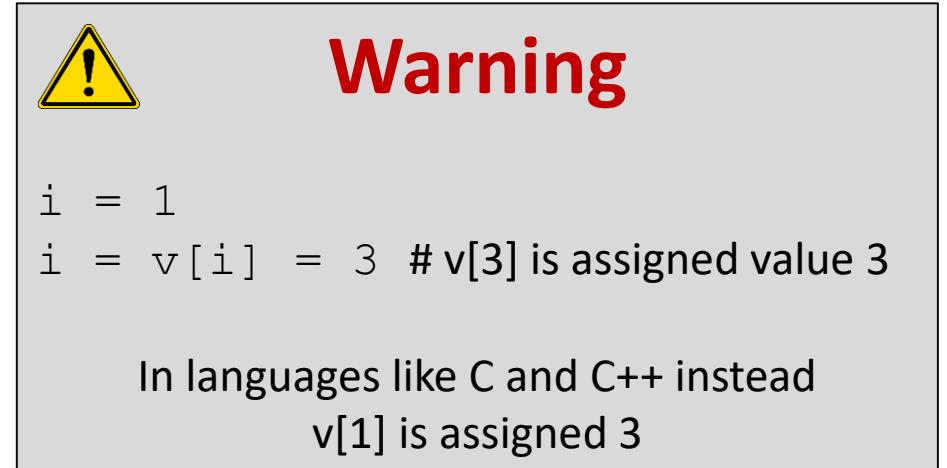
`x, y, z = 2, 5, 7`

- Useful for swapping

`x, y = y, x`

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

`x = y = z = 7`



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'>
```



x new type

Type conversion

- Convert a value to another type:

new-type(value)

- Sometimes done automatically:

$1.0 + 7 = 1.0 + \text{float}(7) = 8.0$

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
```



string
concatenation

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