

# Hello world!

*Get into programming! In this very first activity, you will learn to manipulate numbers, variables and code your first loop with Python.*

## Lesson 1 (Numbers with Python).

Check that Python works correctly, by typing the following commands in the Python console:

```
>>> 2+2
>>> "Hello world!"
```

Here are some instructions to try.

- **Addition.**  $5+7$ .
- **Multiplication.**  $6*7$ ; with brackets  $3*(12+5)$ ; with decimal numbers  $3*1.5$ .
- **Power.**  $3**2$  for  $3^2 = 9$ ; negative power  $10**-3$  for  $10^{-3} = 0.001$ .
- **Real division.**  $14/4$  is equal to  $3.5$ ;  $1/3$  is equal to  $0.3333333333333333$ .
- **Integer division and modulo.**
  - $14//4$  returns 3: it is the quotient of the Euclidean division of 14 by 4, note the double slash;
  - $14\%4$  returns 2: it is the remainder of the Euclidean division of 14 by 4, we also say “14 modulo 4”.

*Note.* Inside the computer, decimals numbers are encoded as “floating point numbers”.

## Activity 1 (First steps).

*Goal: code your first calculations with Python.*

1. How many seconds are there in a century? (Do not take leap years into account.)
2. How far do you have to complete the dotted formula to obtain a number greater than one billion?

$$(1 + 2) \times (3 + 4) \times (5 + 6) \times (7 + 8) \times \dots$$

3. What are the last three digits of

$$123456789 \times 123456789 \times 123456789 \times 123456789 \times 123456789 \times 123456789 \times 123456789 \quad ?$$

4. 7 is the first integer such that its inverse has a repeating decimal representation of period 6:

$$\frac{1}{7} = 0.\underbrace{142857}_{\text{period 6}}\underbrace{142857}_{\text{period 6}}\underbrace{142857}_{\text{period 6}}\dots$$

Find the first integer whose inverse has a repeating decimal representation of period 7:

$$\frac{1}{???} = 0.00\underbrace{abcdefg}_{\text{period 7}}\underbrace{abcdefg}_{\text{period 7}}\dots$$

*Hint.* The integer is bigger than 230!

5. Find the unique integer:

- which gives a quotient of 107 when you divide it by 11 (with integer division),
- and which gives a quotient of 90 when you divide it by 13 (with integer division),
- and which gives a remainder equal to 6 modulo 7.

### Lesson 2 (Working with an editor).

From now on, it is better if you work in a text editor dedicated to Python rather than with the console. You must then explicitly ask to display the result:

```
print(2+2)
print("Hello world!")
```

In the following you continue to write your code in the editor but we will no longer indicate that you must use `print()` to display the results.

### Lesson 3 (Variables).

**Variable.** A **variable** is a name associated with a memory location. It is like a box that is identified by a label. The command “`a = 3`” means that I have a variable “`a`” associated with the value 3.

Here is a first example:

```
a = 3 # One variable
b = 5 # Another variable

print("The sum is",a+b) # Display the sum
print("The product",a*b) # Display the product

c = b**a # New variable...
print(c) # ... that is displayed
```

**Comments.** Any text following the hashtag character “`#`” is not executed by Python but is used to explain the program. It is a good habit to comment extensively on your code.

**Names.** It is very important to give a clear and precise name to the variables. For example, with the right names you should know what the following code calculates:

```
base = 8
height = 3
area = base * height / 2
print(area)
# print(Area) # !! Error !!
```

Attention! Python is case sensitive. So `myvariable`, `Myvariable` and `MYVARIABLE` are different variables.

**Re-assignment.** Imagine you want to keep your daily accounts. You start with  $S_0 = 1000$ , the next day you earn 100, so now  $S_1 = S_0 + 100$ ; the next day you add 200, so  $S_2 = S_1 + 200$ ; then you lose 50, so on the third day  $S_3 = S_2 - 50$ . With Python you can use just one variable `S` for all these operations.

```
S = 1000
S = S + 100
S = S + 200
```

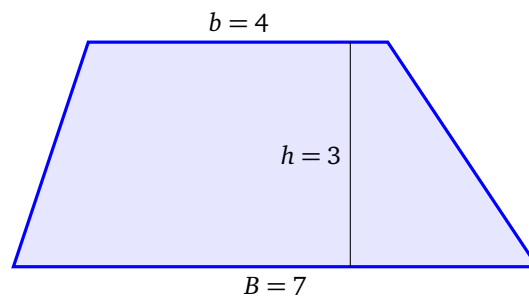
```
S = S - 50
print(S)
```

You have to understand the instruction " $S = S + 100$ " like this: "I take the contents of the box S, I add 100, I put everything back in the same box".

## Activity 2 (Variables).

*Goal: use variables!*

- (a) Define variables, then calculate the area of a trapezoid. Your program should display "The value of the area is ..." using `print("The value of the area is",area)`.



- (b) Define variables to calculate the volume of a box (a rectangular parallelepiped) whose dimensions are 10, 8, 3.
  - (c) Define a variable PI equals to 3.14. Define a radius  $R = 10$ . Write the formula for the area of a disc of radius  $R$ .
- Put the lines back in order so that, at the end,  $x$  has the value 46.

- (1)  $y = y - 1$
- (2)  $y = 2 * x$
- (3)  $x = x + 3 * y$
- (4)  $x = 7$

- You place the sum of 1000 dollars in a savings account. Each year the interest on the money invested brings in 10% (the capital is multiplied by 1.10). Write the code to calculate the capital for the first three years.
- I define two variables by  $a = 9$  and  $b = 11$ . I would like to exchange the content of  $a$  and  $b$ . Which instructions should I use so that at the end  $a$  equals 11 and  $b$  equals 9?

$a = b$	$c = b$	$c = a$	$c = a$
$b = a$	$a = b$	$a = b$	$a = c$
	$b = c$	$b = c$	$c = b$
			$b = c$

## Lesson 4 (Use functions).

- Use Python **functions**.

You already know the `print()` function that displays a string of characters (or numbers). It can be used by `print("Hi there.")` or through a value:

```
string = "Hi there."
print(string)
```

There are many other functions. For example, the function `abs()` calculates the absolute value of a number: for example `abs(-3)` returns 3, `abs(5)` returns 5.

- **The module `math`.**

Not all functions are directly accessible. They are often grouped into **modules**. For example, the `math` module contains mathematical functions. For instance, you will find the square root function `sqrt()`. Here's how to use it:

```
from math import *

x = sqrt(2)
print(x)
print(x**2)
```

The first line imports all the functions of the module named `math`, the next lines calculate  $x = \sqrt{2}$  (as an approximate value) and then display  $x$  and  $x^2$ .

- **Sine and cosine.**

The `math` module contains the trigonometric functions `sine` and `cosine` and even the constant `pi` which is an approximate value of  $\pi$ . Be careful, the angles are expressed in radians. Here is the calculation of  $\sin(\frac{\pi}{2})$ .

```
angle = pi/2
print(angle)
print(sin(angle))
```

- **Decimal to integer.**

In the `math` module there are also functions to round a decimal number:

- `round()` rounds to the nearest integer: `round(5.6)` returns 6, `round(1.5)` returns 2.
- `floor()` returns the integer less than or equal to: `floor(5.6)` returns 5.
- `ceil()` returns the integer greater than or equal to: `ceil(5.6)` returns 6.

### Activity 3 (Use functions).

*Goal: use functions from Python and the `math` module.*

1. The Python function for gcd is `gcd(a,b)` (for greatest common divisor). Calculate the gcd of  $a = 10\,403$  and  $b = 10\,506$ . Deduce the lcm from  $a$  and  $b$ . The function `lcm` does not exist, you must use the formula :

$$\text{lcm}(a, b) = \frac{a \times b}{\text{gcd}(a, b)}.$$

2. By trial and error, find a real number  $x$  that checks all the following conditions (several solutions are possible):
  - `abs(x**2 - 15)` is less than 0.5

- `round(2*x)` returns 8
- `floor(3*x)` returns 11
- `ceil(4*x)` returns 16

*Hint.* `abs()` refers to the absolute value function.

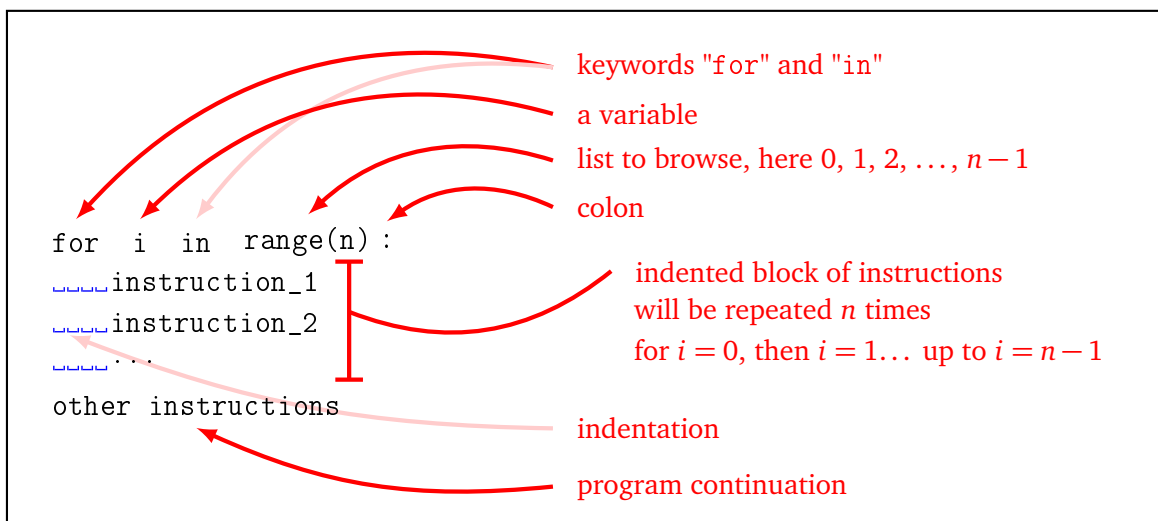
3. You know the trigonometric formula

$$\cos^2 \theta + \sin^2 \theta = 1.$$

Check that for  $\theta = \frac{\pi}{7}$  (or other values) this formula is numerically true (this is not a proof of the formula, because Python only makes approximate computations of the sine and cosine).

## Lesson 5 (“for” loop).

*The “for” loop is the easiest way to repeat instructions.*



Note that what delimits the block of instructions to be repeated is **indentation**, i.e. the spaces at the beginning of each line that shift the lines to the right. All lines in a block must have exactly the same indentation. In this book, we choose an indentation of 4 spaces.

Don't forget the colon “:” at the end of the line of the `for` declaration!

### • Example of a “for” loop.

Here is a loop that displays the squares of the first integers.

```

for i in range(10):
    print(i*i)
  
```

The second line is shifted and constitutes the block to be repeated. The variable `i` takes the value 0 and the instruction displays  $0^2$ ; then `i` takes the value 1, and the instruction displays  $1^2$ ; then  $2^2$ ,  $3^2$ ...

In the end this program displays:

0, 1, 4, 9, 16, 25, 36, 49, 64, 81.

Warning: the last value taken by `i` is 9 (and not 10).

### • Browse any list.

The “for” loop allows you to browse any list. Here is a loop that displays the cube of the first prime numbers.

```
for p in [2,3,5,7,11,13]:
    print(p**3)
```

- **Sum all.**

Here is a program that calculates

$$0 + 1 + 2 + 3 + \dots + 18 + 19.$$

```
mysum = 0
for i in range(20):
    mysum = mysum + i
print(mysum)
```

Understand this code well: a variable `mysum` is initialized at 0. We will add 0, then 1, then 2... This loop can be better understood by filling in a table:

Initialisation: `mysum= 0`

i	mysum
0	0
1	1
2	3
3	6
4	10
...	...
18	171
19	190

Display: 190

- `range()`.

- With `range(n)` we run the entire range from 0 to  $n - 1$ . For example `range(10)` corresponds to the list `[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]`.

Attention! the list stops at  $n - 1$  and not at  $n$ . What to remember is that the list contains  $n$  items (because it starts at 0).

- If you want to display the list of items browsed, you must use the command:

```
list(range(10))
```

- With `range(a,b)` we go through the elements from  $a$  to  $b - 1$ . For example `range(10,20)` corresponds to the list `[10, 11, 12, 13, 14, 15, 16, 17, 18, 19]`.

- With `range(a,b,step)` you can browse the items  $a, a + \text{step}, a + 2\text{step} \dots$ . For example `range(10,20,2)` corresponds to the list `[10, 12, 14, 16, 18]`.

- **Nested loops.**

It is possible to nest loops, i.e. use a loop inside the block of another loop.

```
for x in [10,20,30,40,50]:
    for y in [3,7]:
        print(x+y)
```

In this small program  $x$  is first equal to 10,  $y$  takes the value 3 then the value 7 (so the program displays 13, then 17). Then  $x = 20$ , and  $y$  again equals 3, then 7 again (so the program displays 23, then 27). Finally the program displays:

13, 17, 23, 27, 33, 37, 43, 47, 53, 57.

#### Activity 4 (“for” loop).

*Goal: build simple loops.*

- (a) Display the cubes of integers from 0 to 100.  
(b) Display the fourth powers of integers from 10 to 20.  
(c) Display the square roots of integers 0, 5, 10, 15, ... up to 100.
- Display the powers of 2, from  $2^1$  to  $2^{10}$ , and memorize the results!
- Experimentally search for a value close to the minimum of the function

$$f(x) = x^3 - x^2 - \frac{1}{4}x + 1$$

on the interval  $[0, 1]$ .

*Hints.*

- Build a loop in which a variable  $i$  scans integers from 0 to 100.
  - Defined  $x = \frac{i}{100}$ . So  $x = 0.00$ , then  $x = 0.01$ ,  $x = 0.02$ ...
  - Calculate  $y = x^3 - x^2 - \frac{1}{4}x + 1$ .
  - Display the values using `print("x =", x, "y =", y)`.
  - Search by hand for which value of  $x$  you get the smallest possible  $y$ .
  - Feel free to modify your program to increase accuracy.
- Seek an approximate value that must have the radius  $R$  of a ball so that its volume is 100.

*Hints.*

- Use a scanning method as in the previous question.
- The formula for the volume of a ball is  $V = \frac{4}{3}\pi R^3$ .
- Display values using `print("R =", R, "V =", V)`.
- For  $\pi$  you can take the approximate value 3.14 or the approximate value `pi` of the `math` module.

#### Activity 5 (“for” loop (continued)).

*Goal: build more complicated loops.*

- Define a variable  $n$  (for example  $n = 20$ ). Calculate the sum

$$1^2 + 2^2 + 3^2 + \dots + i^2 + \dots + n^2.$$

- Calculate the product:

$$1 \times 3 \times 5 \times \dots \times 19.$$

*Hints.* Begin by defining a variable `myproduct` initialized to the value 1. Use `range(a, b, 2)` to get every other integer.

- Display multiplication tables between 1 and 10. Here is an example of a line to display:

$$7 \times 9 = 63$$

Use a display command of the style: `print(a, "x", b, "=", a*b)`.