

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
```

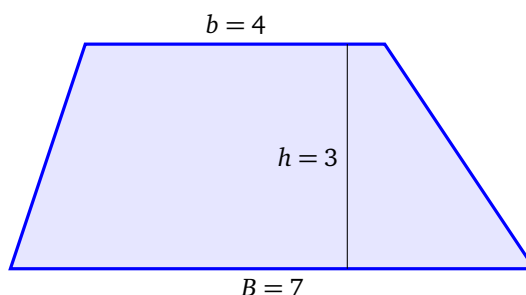
```
S = S - 50
print(S)
```

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 π 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 second line calculates $x = \sqrt{2}$ (as an approximate value) and then displays 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 π . 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.

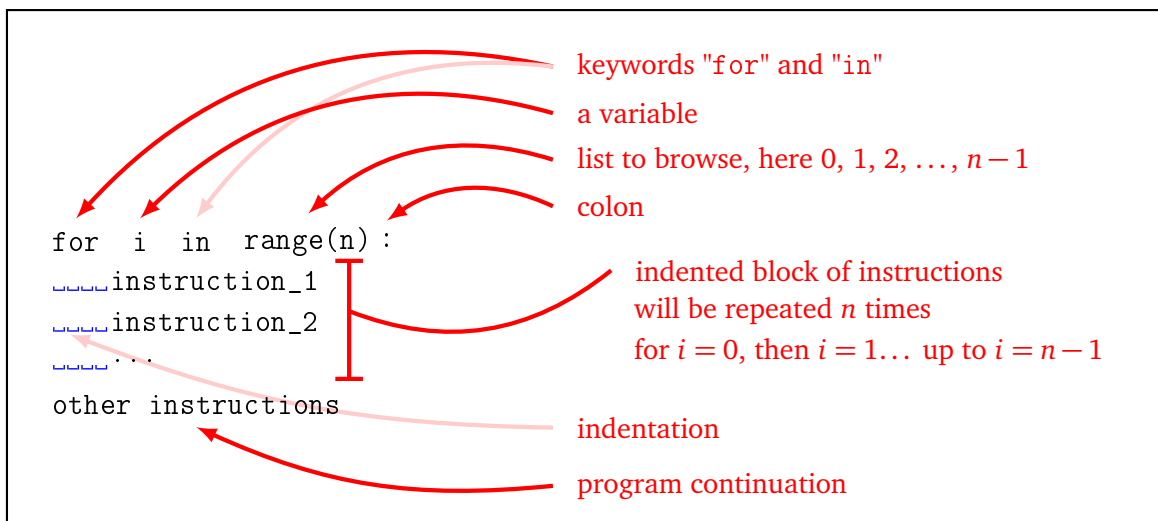
3. You know the trigonometric formula

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

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 , $3^2 \dots$

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 π 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)`.