Functions

- What is a function?
- Why use functions?
- How to define and call functions?
- Keyword Arguments
- Default Argument Values
- Functions vs Methods
- Arbitrary Argument Lists

What is a function?

A function is a **block of organized, reusable code** that is used to **perform a single, specific task**. It performs actions on input data (arguments) and returns a result if necessary.

Why use functions?

- **Reusability**: functions are reusable blocks of code and allow to avoid copy/paste which is a dangerous practice and pollutes the code.

- **Organization**: functions help to organize your model. As a model grows in complexity, having all the code live inside a "main" script becomes increasingly complicated. Using functions allows to divide complicated tasks into smaller, simpler ones, and reduce the overall complexity of your model.

- **Abstraction**: Functions can be used as "black boxes", you don't need to know what is inside to use them. To use a function, you just need to know its name (= what it is supposed to do), the input arguments and the optional output.

- **IDE-Tools**: take advantage of tools provided by most IDE software.

How to define and call functions?

How to define functions?

```
def function_name(arguments):
    """function documentation = docstring (optional)"""
    <function code>
    # optional
    return [variable(s) or expression]
```

- Function blocks begin with the keyword **def** followed by the **function name**, parentheses **( )** and a colon **:**
- Input **arguments**, if any, are placed within these parentheses.
- The code block within every function is indented.
- A function can optionally start by its **documentation**: a string written between triple quotes """ (multiple lines documentation is allowed).
- The optional statement **return [variable(s) or expression]** exits a function and returns output result(s).

Let's begin with a simple function with no input arguments and returning nothing:

In [1]:
```
def it_helpdesk():
    """Print universal solution to any computer problem"""
    print("Have you tried to turn it off and on again?")
```

Function with an input argument:

In [2]:
```
def it_helpdesk(problem):
    print("Thank you for your request for support concerning:")
    print(problem)
    print("Before we do anything, have you tried to turn it off and on again?")
```

Function returning something:

In [3]:

```
# (case 1) function returning an expression
def it_helpdesk():
    return "Have you tried to turn it off and on again?"

# (case 2) function returning a variable
def it_helpdesk():
    answer = "Have you tried to turn it off and on again?"
    return answer
```

Function with an input argument and returning something:

In [4]:
```
def it_helpdesk(problem):
    answer = "Thank you for your request for support concerning:\n"
    answer = answer + problem + "\n"
    answer = answer + "Before we do anything, have you tried to turn it off and on ag
ain?"
    return answer
```

How to call functions?

```
def function_name(...):
    ...

# function with no input argument and returning nothing
function_name()
# function with input arguments and returning nothing
function_name(arguments)
# function with input arguments and returning a result
res = function_name(arguments)
```

- To call a function, simply type its name followed by parentheses ().
- If the function requires input arguments, you need to provide values for them inside the parentheses. Theses values can be constants or expressions.
- If the function returns a result, it can be stored in a variable by preceding the function name with a variable name.

Function with no input arguments:

In [5]:
```
def it_helpdesk():
    print("Have you tried to turn it off and on again?")

# call and execute function "it_helpdesk()"
it_helpdesk()
```

```
Have you tried to turn it off and on again?
```

Function with an input argument:

In [6]:
```
def it_helpdesk(problem):
    print("Thank you for your request for support concerning:")
    print(problem)
    print("Before we do anything, have you tried to turn it off and on again?")

# call function "it_helpdesk" and pass a string as input argument
it_helpdesk("My computer smells weird and is very hot")
```

```
Thank you for your request for support concerning:
My computer smells weird and is very hot
Before we do anything, have you tried to turn it off and on again?
```

In [7]:

```
print("\n10 minutes later...\n")

# call function "it_helpdesk" and a variable
# (!) the name of the passed variable can be different from
#     the name of the input argument
my_problem = "My computer is on fire!"
it_helpdesk(my_problem)
```

```
10 minutes later...

Thank you for your request for support concerning:
My computer is on fire!
Before we do anything, have you tried to turn it off and on again?
```

Function returning something:

In [8]:
```
def it_helpdesk():
    return "Have you tried to turn it off and on again?"

# call function "it_helpdesk"
it_answer = it_helpdesk()
print(it_answer)
```

```
Have you tried to turn it off and on again?
```

Function with an input argument and returning something:

In [9]:

```
def it_helpdesk(problem):
    answer =  "Thank you for your request for support concerning:\n"
    answer = answer + problem + "\n"
    answer = answer + "Before we do anything, have you tried to turn it off and on ag
ain?"
    return answer

# call function "it_helpdesk" and pass a string as input argument
it_answer = it_helpdesk("My computer smells weird and is very hot")
print(it_answer)
```

```
Thank you for your request for support concerning:
My computer smells weird and is very hot
Before we do anything, have you tried to turn it off and on again?
```

In [10]:

```
print("\n10 minutes later...\n")

# call function "it_helpdesk" and a variable
# (!) the name of the passed variable can be different from
#     the name of the input argument
user_problem = "My computer is on fire!"
it_answer = it_helpdesk(user_problem)
print(it_answer)
```

```
10 minutes later...

Thank you for your request for support concerning:
My computer is on fire!
Before we do anything, have you tried to turn it off and on again?
```

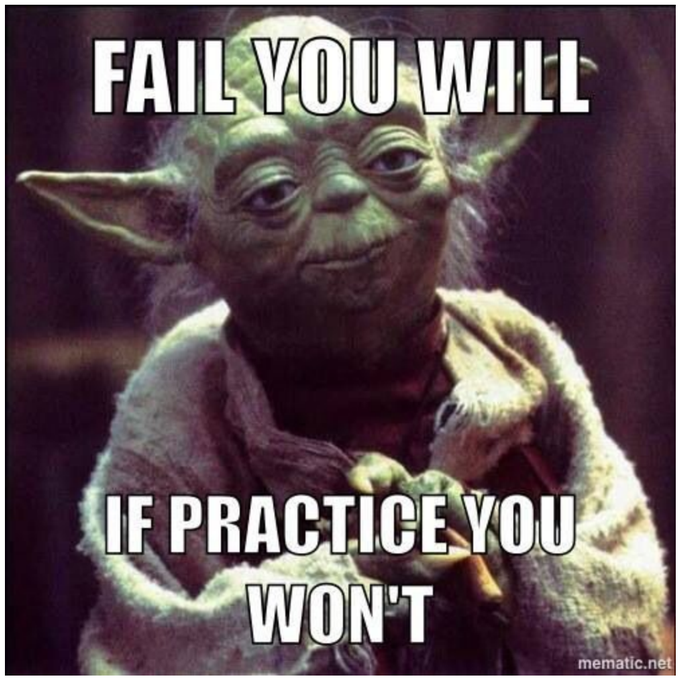
Note: a function can return several values:

In [11]:
```
# Note: this function already exists in Python
def divmod(a, b):
    return a // b, a % b

quotient, remainder = divmod(5, 2)
print(quotient, remainder)
```

```
2 1
```

Time to practice

Do exercices 1, 2, 3 and 4.



Keyword Arguments

It is possible to pass input arguments to a function using the syntax **keyword=value**:

In [12]:
```
def can_i_trust_this_website(website, country):
    if country == 'US' and 'foxnews' in website:
        print("Yes")
    else:
        print("No! It's all fake news!")

# call function can_i_trust_this_website using "keywords arguments"
can_i_trust_this_website(website="http://www.plan.be", country="Belgium")
```

```
No! It's all fake news!
```

In that case, arguments can be passed in any order:

In [13]:
```
# call function can_i_trust_this_website and pass input arguments in reverse order
can_i_trust_this_website(country="Belgium", website="http://www.plan.be")
```

```
No! It's all fake news!
```

It is even possible to mix positional and keyword arguments:

In [14]:
```
can_i_trust_this_website("http://www.plan.be", country="Belgium")
```

```
No! It's all fake news!
```

WARNING: positional arguments must always be passed first

In [15]:
```
can_i_trust_this_website(website="http://www.plan.be", "Belgium")
```

```
  File "<ipython-input-15-ea4a27a80b58>", line 1
    can_i_trust_this_website(website="http://www.plan.be", "Belgium")
                                                          ^
SyntaxError: positional argument follows keyword argument
```

Time to practice

Do exercice 5.

Default Argument Values

It is possible to set a default value to some arguments of a function:

In [16]:
```
def can_i_trust_this_website(website, country='Belgium'):
    if country == 'US' and 'foxnews' in website:
        print("Yes")
    else:
        print("No! It's all fake news!")

# if no value is passed for the "country" argument,
# it will be set to "Belgium" by default
can_i_trust_this_website("http://www.plan.be")
```

```
No! It's all fake news!
```

WARNING: arguments with default values must always be declared after all the others:

In [17]:
```
# Wrong function definition --> arguments with default values must always
# be placed at the end of the arguments list
def can_i_trust_this_website(website="http://www.foxnews.com", country):
    if country == 'US' and 'foxnews' in website:
        print("Yes")
    else:
        print("No! It's all fake news!")

can_i_trust_this_website("Belgium")
```

```
  File "<ipython-input-17-9f6e5ff0eef6>", line 3
    def can_i_trust_this_website(website="http://www.foxnews.com", country):
                                                                  ^
SyntaxError: non-default argument follows default argument
```

What about default value of arguments of type list, dictionary or array (*mutable* objects)?

In [18]:
```
# Wrong function defintion --> default value for mutable input arguments
# should be None and initialized inside the function
def new_list_wrong_way(value, new_list=[]):
    new_list.append(value)
    return new_list

result_1 = new_list_wrong_way(1)
print('Expected [1]. Got:', result_1)
result_2 = new_list_wrong_way(2)
print('Expected [2]. Got:', result_2)
result_3 = new_list_wrong_way(3)
print('Expected [3]. Got:', result_3)
```

```
Expected [1]. Got: [1]
Expected [2]. Got: [1, 2]
Expected [3]. Got: [1, 2, 3]
```

The default value is evaluated only once. This leads to an unexpected behavior when the default value is an object of composed type such as a list or dictionary.

WARNING: To define a function with arguments having a list, a dictionary or an array as default value, use **None** as the default value in the function definition and and **set the default value at the beginning of the function**:

In [19]:

```python
# Right way
def new_list_right_way(a, new_list=None):
    if new_list is None:
        new_list = []
    new_list.append(a)
    return new_list

result_1 = new_list_right_way(1)
print('Expected [1]. Got:', result_1)
result_2 = new_list_right_way(2)
print('Expected [2]. Got:', result_2)
result_3 = new_list_right_way(3)
print('Expected [3]. Got:', result_3)
```

```
Expected [1]. Got: [1]
Expected [2]. Got: [2]
Expected [3]. Got: [3]
```

Note: Keywords arguments and default argument values are two different things:

- **Keywords arguments**: "name=value" in **function call**
- **Default argument values**: "name=value" in **function definition**

An argument without a default value can be passed as keyword argument and an argument with default value can be used like any positional argument:

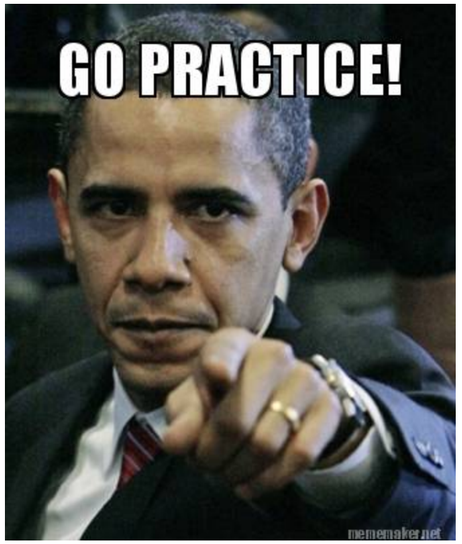
In [20]:

```
def function_with_default_argument_value(positional_arg, arg_with_default_value="argu
ment with a default value"):
    print(positional_arg)
    print(arg_with_default_value)
    print()

# An argument without a default value can be passed as keyword argument
function_with_default_argument_value(positional_arg="positional arg passed as keyword
 argument")

# An argument with default value can be used like any positional argument
function_with_default_argument_value("positional arg", "override default value")
```

```
positional arg passed as keyword argument
argument with a default value

positional arg
override default value
```

Time to practice

Do exercice 6.



Functions vs Methods

A method is a function called on a object using the syntax `object.method(arguments)`:

In [21]:
```
from larray import ones

pop = ones('age=0..5')
print(pop)

# call method 'sum' on object 'pop'
total_pop = pop.sum('age')
print()
print("total population:", total_pop)
```

```
age    0    1    2    3    4    5
     1.0  1.0  1.0  1.0  1.0  1.0

total population: 6.0
```

Arbitrary Argument Lists

Some functions or methods have special input arguments `*args` and `**kwargs`.

A function which has such arguments can have an arbitrary number of arguments:

- `*args` for positional arguments (arguments passed without keyword)

In [22]:
```
def function_with_arbitrary_positional_arguments(*args):
    # passed arguments are converted to a tuple
    print(args)

function_with_arbitrary_positional_arguments(0, 1, 2, 3, 4)
```

```
(0, 1, 2, 3, 4)
```

- **kwargs for keyword arguments

In [23]:
```
def function_with_arbitrary_keyword_arguments(**kwargs):
    # passed arguments are converted to a dictionary
    print(kwargs)

function_with_arbitrary_keyword_arguments(firstname='Sarah', name='Connor', country=
'US')
```

```
{'firstname': 'Sarah', 'name': 'Connor', 'country': 'US'}
```

The builder method for Session is a good example:

In [24]:
```
from larray import Axis, Session, ones

# define axes
AGE = Axis('age = 0..5')
GENDER = Axis('gender = F,M')
COUNTRY = Axis('country = BE,FR,IT,UK')
# define arrays
pop_be = ones((AGE, GENDER))
pop_by_age = ones((AGE, COUNTRY))
pop_all = ones((AGE, GENDER, COUNTRY))
```

In [25]:

```
# store axes and arrays in a session
# Session builder accepts an arbitrary number of axes and arrays.
# Axes are passed first and separated with commas (*args).
# Arrays are then passed as keyword arguments (**kwargs).
ses = Session(AGE, GENDER, COUNTRY, pop_be=pop_be, pop_by_age=pop_by_age, pop_all=pop
_all)

print(ses)
```

```
Session(age, gender, country, pop_be, pop_by_age, pop_all)
```

More infos on defining functions?

See the official documentation of Python (3.5)