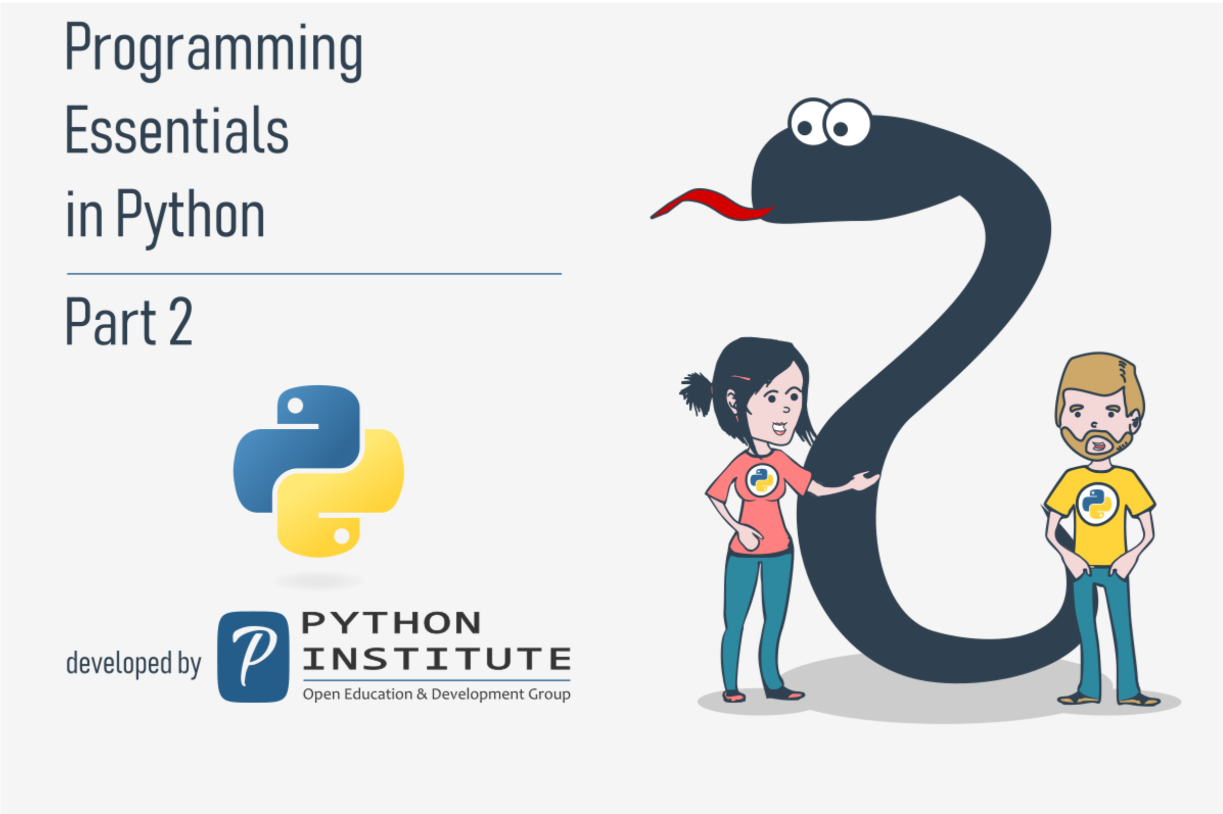
Welcome to Programming Essentials in Python - Part 2

Module 5

Modules, packages, string and list methods, and exceptions

Module 6

The Object-Oriented Approach: classes, methods, objects and the standard objective features; exception handling, and working with files



Programming Essentials in Python: Module

In this module, you will learn about:

- Python modules: their rationale, function, how to import them in different ways, and present the content of some standard modules provided by Python;
- the way in which modules are coupled together to make packages.
- the concept of an exception and Python's implementation of it, including the try-except instruction, with its applications, and the raise instruction.
- strings and their specific methods, together with their similarities and differences compared to lists.

Using Modules

What is a module?

Computer code has a tendency to grow. We can say that code that doesn't grow is probably completely unusable or abandoned. A real, wanted, and widely used code develops continuously, as both users' demands and users' expectations develop in their own rhythms.

A code which is not able to respond to users' needs will be forgotten quickly, and instantly replaced with a new, better, and more flexible code. Be prepared for this, and never think that any of your programs is eventually completed. The completion is a transition state and usually passes quickly, after the first bug report. Python itself is a good example how the rule acts.

Growing code is in fact a growing problem. A larger code always means tougher maintenance. Searching for bugs is always easier where the code is smaller (just as finding a mechanical breakage is simpler when the machinery is simpler and smaller).

Moreover, when the code being created is expected to be really big (you can use a total number of source lines as a useful, but not very accurate, measure of a code's size) you may want (or rather, you will be forced) to divide it into many parts, implemented in parallel by a few, a dozen, several dozen, or even several hundred individual developers.

Of course, this cannot be done using one large source file, which is edited by all programmers at the same time. This will surely lead to a spectacular disaster.

If you want such a software project to be completed successfully, you have to have the means allowing you to:

- divide all the tasks among the developers;
- join all the created parts into one working whole.

For example, a certain project can be divided into two main parts:

- the user interface (the part that communicates with the user using widgets and a graphical screen)
- the logic (the part processing data and producing results)

Each of these parts can be (most likely) divided into smaller ones, and so on. Such a process is often called **decomposition**.

For example, if you were asked to arrange a wedding, you wouldn't do everything yourself **-** you would find a number of professionals and split the task between them all.

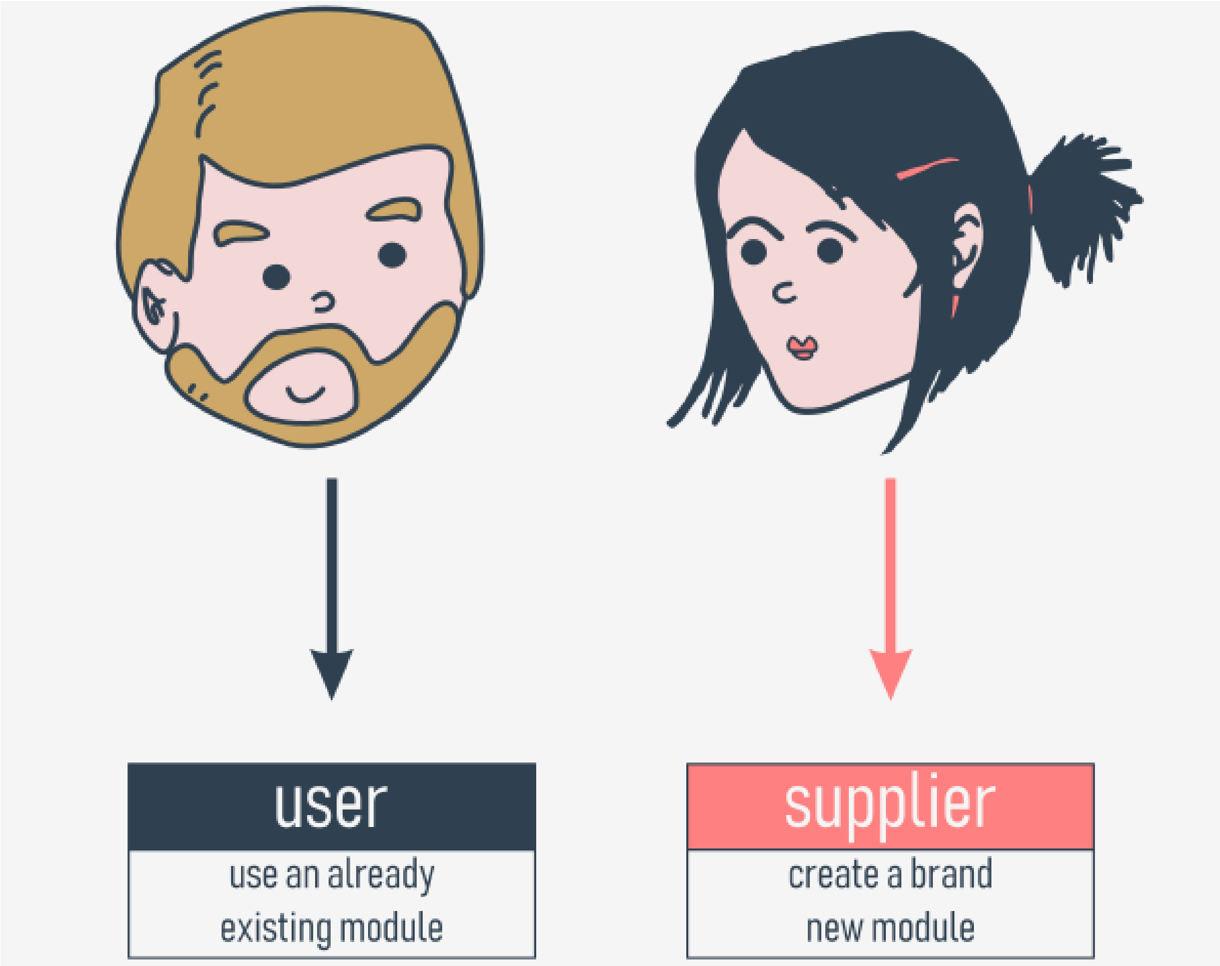
How do you divide a piece of software into separate but cooperating parts? This is the question. **Modules** are the answer.

How to make use of a module?

The handling of modules consists of two different issues:

- the first (probably the most common) happens when you want to use an already existing module, written by someone else, or created by yourself during your work on some complex project **-** in this case you are the module's **user**;
- the second occurs when you want to create a brand new module, either for your own use, or to make other programmers' lives easier **-** you are the module's **supplier**.

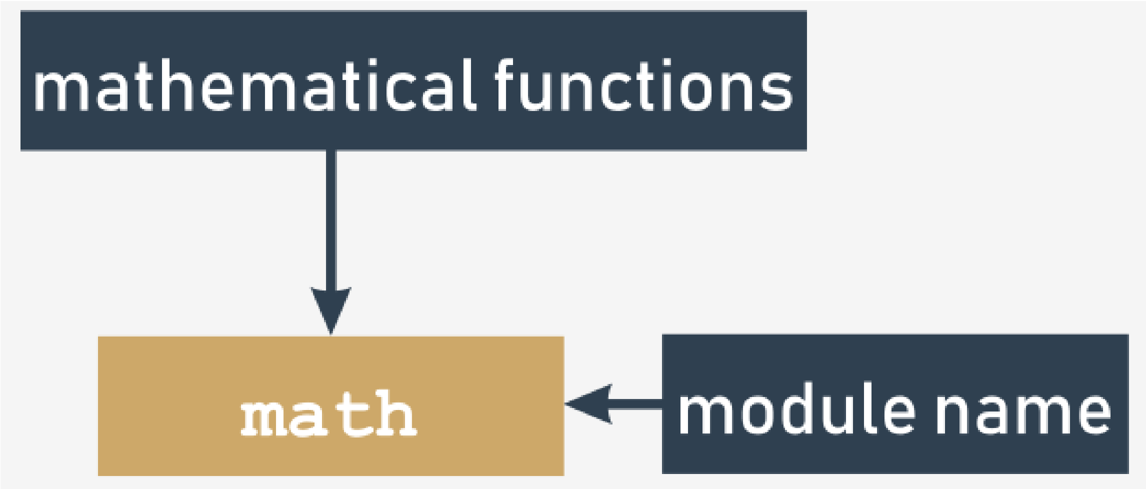
Let's discuss them separately.



First of all, a module is identified by its **name**. If you want to use any module, you need to know the name. A (rather large) number of modules is delivered together with Python itself. You can think of them as a kind of "Python extra equipment".

All these modules, along with the built-in functions, form the **Python standard library -** a special sort of library where modules play the roles of books (we can even say that folders play the roles of shelves). If you want to take a look at the full list of all "volumes" collected in that library, you can find it here: https://docs.python.org/3/library/index.html.

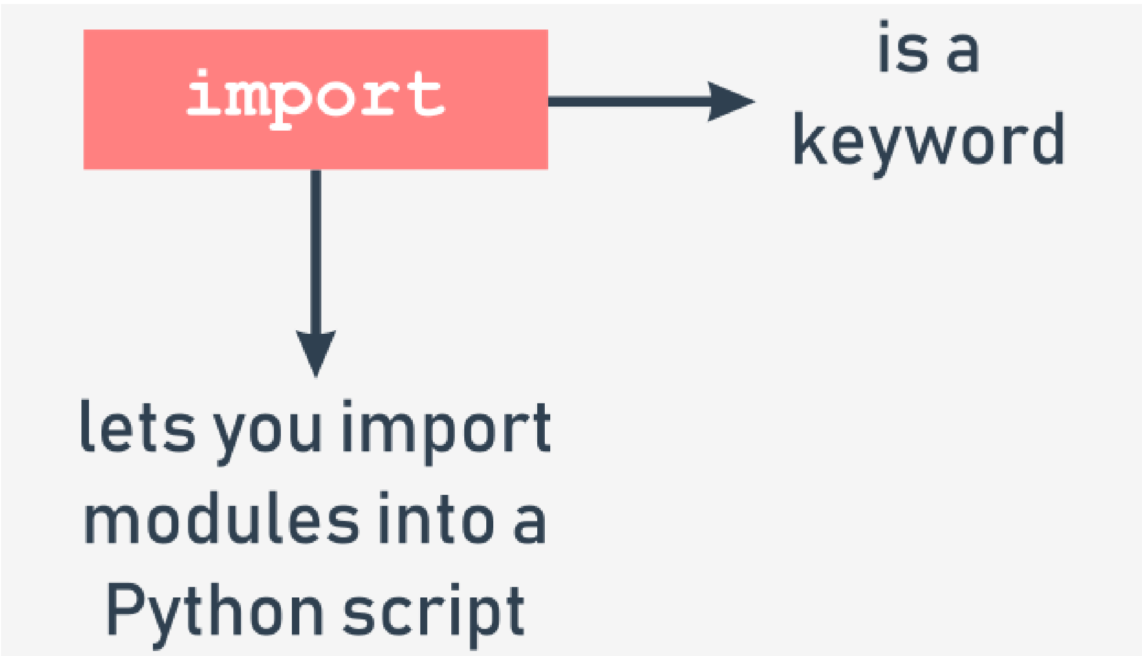
Each module consists of entities (like a book consists of chapters). These entities can be functions, variables, constants, classes, and objects. If you know how to access a particular module, you can make use of any of the entities it stores.



Let's start the discussion with one of the most frequently used modules, named `math`. Its name speaks for itself - the module contains a rich collection of entities (not only functions) which enable a programmer to effectively implement calculations demanding the use of mathematical functions, like *sin()* or *log()*.

Importing a module

To make a module usable, you must **import** it (think of it like of taking a book off the shelf). Importing a module is done by an instruction named `import`. Note: `import` is also a keyword (with all the consequences of this fact).



Let's assume that you want to use two entities provided by the `math` module:

- a symbol (constant) representing a precise (as precise as possible using double floating-point arithmetic) value of π (although using a Greek letter to name a variable is fully possible in Python, the symbol is named **pi** - it's a more convenient solution, especially for that part of the world which neither has nor is going to use a Greek keyboard)
- a function named `sin()` (the computer equivalent of the mathematical *sine* function)

Both these entities are available through the `math` module, but the way in which you can use them strongly depends on how the import has been done.

The simplest way to import a particular module is to use the import instruction as follows:

`import math`

The clause contains:

- the `import` keyword;
- the **name of the module** which is subject to import.

The instruction may be located anywhere in your code, but it must be placed **before the first use of any of the module's entities**.

If you want to (or have to) import more than one module, you can do it by repeating the `import` clause, or by listing the modules after the `import` keyword, like here:

`import math, sys`

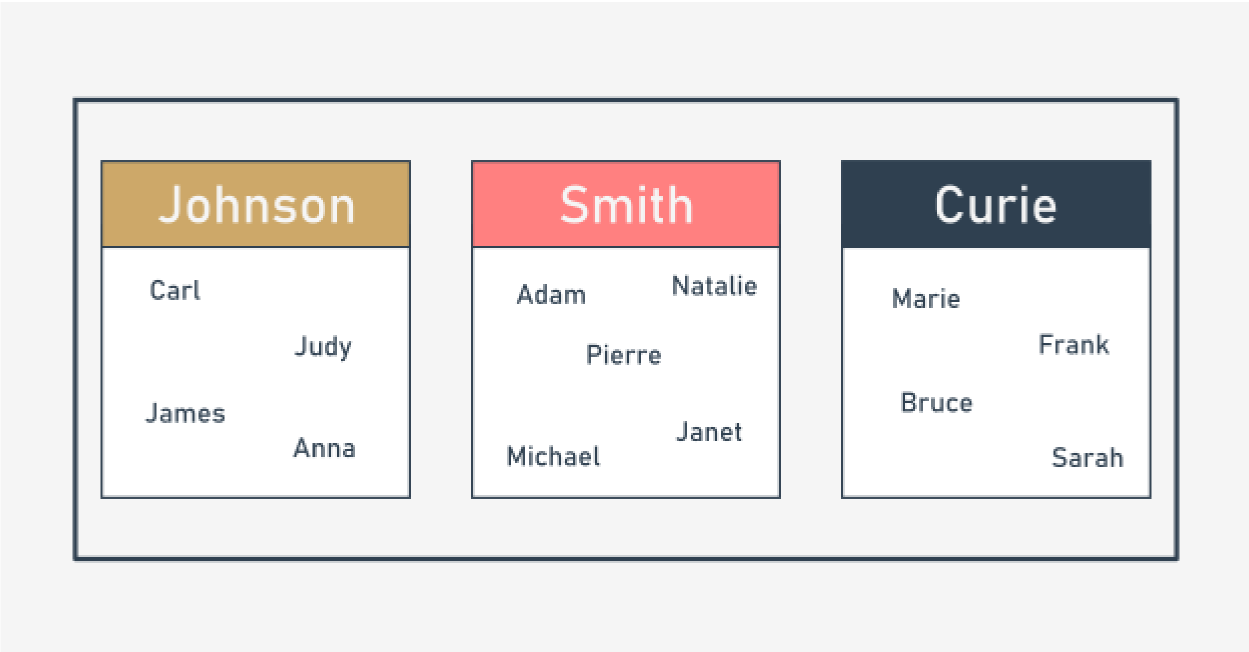
The instruction imports two modules, first the one named math and then the second named `sys`.

The modules' list may be arbitrarily long.

To continue, you need to become familiar with an important term: **namespace**.

Don't worry, we won't go into great detail - this explanation is going to be as short as possible.

A **namespace** is a space (understood in a non-physical context) in which some names exist and the names don't conflict with each other (i.e., there are not two different objects of the same name). We can say that each social group is a namespace - the group tends to name each of its members in a unique way (e.g., parents won't give their children the same first names).

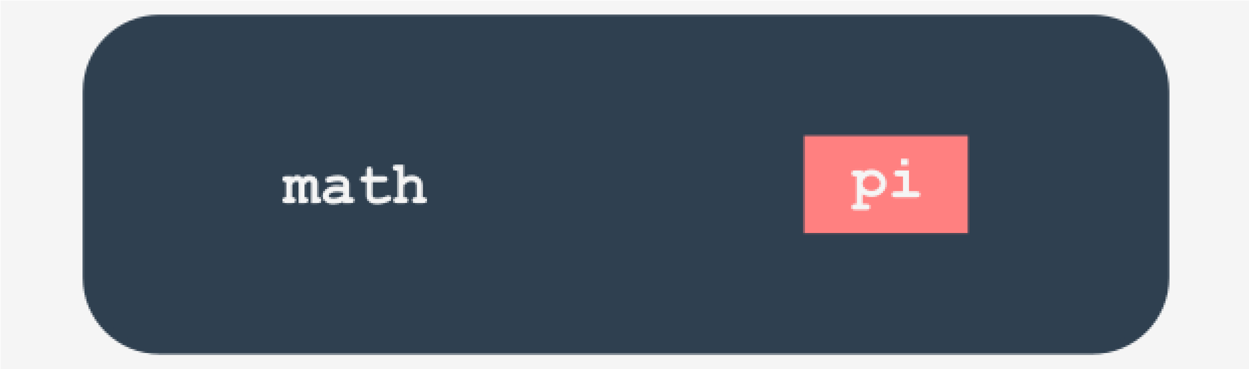


This uniqueness may be achieved in many ways, e.g., by using nicknames along with the first names (it will work inside a small group like a class in a school) or by assigning special identifiers to all members of the group (the US Social Security Number is a good example of such practice).

Inside a certain namespace, each name must remain unique. This may mean that some names may disappear when any other entity of an already known name enters the namespace. We'll show you how it works and how to control it, but first, let's return to imports.

If the module of a specified name **exists and is accessible** (a module is in fact a **Python source file**), Python imports its contents, i.e., **all the names defined in the module become known**, but they don't enter your code's namespace.

This means that you can have your own entities named `sin` or `pi` and they won't be affected by the import in any way.



At this point, you may be wondering how to access the `pi` coming from the `math` module.

To do this, you have to qualify the `pi` with the name of its original module.

Look at the snippet below, this is the way in which you qualify the names of `pi` and `sin` with the name of its originating module:

```
math.pi
math.sin
```

It's simple, you put:

- the **name of the module** (`math` here)
- a **dot**;
- the **name of the entity** (`pi` here)

Such a form clearly indicates the namespace in which the name exists.

Note: using this qualification is **compulsory** if a module has been imported by the `import` module instruction. It doesn't matter if any of the names from your code and from the module's namespace are in conflict or not.

This first example won't be very advanced - we just want to print the value of **sin(1/2π)**.

Look at the code below. This is how we test it.

```
import math
print(math.sin(math.pi/2))
```

The code outputs the expected value: `1.0`.

Note: removing any of the two qualifications will make the code erroneous. There is no other way to enter `math`'s namespace if you did the following:

```
import math
```

Now we're going to show you how the two namespaces (yours and the module's one) can coexist.

Take a look at the example below.

```
import math

def sin(x):
    if 2 * x == pi:
        return 0.99999999
    else:
        return None

pi = 3.14

print(sin(pi/2))
print(math.sin(math.pi/2))
```

We've defined our own `pi` and `sin` here.

Run the program. The code should produce the following output:

```
0.99999999
1.0
```

As you can see, the entities don't affect each other.

In the second method, the `import`'s syntax precisely points out which module's entity (or entities) are acceptable in the code:

```
from math import pi
```

The instruction consists of the following elements:

- the `from` keyword;
- the **name of the module** to be (selectively) imported;
- the `import` keyword;
- the **name or list of names of the entity/entities** which are being imported into the namespace.

The instruction has this effect:

- the listed entities (and only those ones) are **imported from the indicated module**;
- the names of the imported entities are **accessible without qualification**.

Note: no other entities are imported. Moreover, you cannot import additional entities using a qualification - a line like this one:

```
print(math.e)
```

will cause an error (`e` is Euler's number: 2.71828...)

Let's rewrite the previous script to incorporate the new technique.

Here it is:

```
from math import sin, pi
print(sin(pi/2))
```

The output should be the same as previously, as in fact we've used the same entities as before: `1.0`. Copy the code, paste it in the editor, and run the program.

Does the code look simpler? Maybe, but the look is not the only effect of this kind of import. Let's show you that.

Look at the code in the editor. Analyze it carefully:

```
1  from math import sin, pi
2
3  print(sin(pi/2))
4
5  pi = 3.14
6
7  def sin(x):
8      if 2 * x == pi:
9          return 0.99999999
10     else:
11         return None
12
13 print(sin(pi/2))
```

- line 01: carry out the selective import;
- line 03: make use of the imported entities and get the expected result (`1.0`)
- lines 05 through 11: redefine the meaning of `pi` and `sin` - in effect, they supersede the original (imported) definitions within the code's namespace;
- line 13: get `0.99999999`, which confirms our conclusions.

Let's do another test. Look at the code below:

```
pi = 3.14           # line 01
def sin(x):
      if 2 * x == pi:
            return 0.99999999
      else:
            return None      # line 07
print(sin(pi/2))       # line 09
from math import sin, pi     # line 12
print(sin(pi/2))       # line 14
```

Here, we've reversed the sequence of the code's operations:

- lines 01 through 07: define our own `pi` and `sin`;
- line 09: make use of them (0.99999999 appears on screen)

- line 12: carry out the import - the imported symbols supersede their previous definitions within the namespace;
- line 14: get `1.0` as a result.

In the third method, the `import`'s syntax is a more aggressive form of the previously presented one:

```
from module import *
```

As you can see, the name of an entity (or the list of entities' names) is replaced with a single asterisk (`*`).

Such an instruction **imports all entities from the indicated module**.

Is it convenient? Yes, it is, as it relieves you of the duty of enumerating all the names you need.

Is it unsafe? Yes, it is - unless you know all the names provided by the module, **you may not be able to avoid name conflicts**. Treat this as a temporary solution, and try not to use it in regular code.

Importing a module: the `as` keyword

If you use the import module variant and you don't like a particular module's name (e.g., it's the same as one of your already defined entities, so qualification becomes troublesome) you can give it any name you like - this is called **aliasing**.

Aliasing causes the module to be identified under a different name than the original. This may shorten the qualified names, too.

Creating an alias is done together with importing the module, and demands the following form of the import instruction:

```
import module as alias
```

The "module" identifies the original module's name while the "alias" is the name you wish to use instead of the original.

Note: `as` is a keyword.

If you need to change the word `math`, you can introduce your own name, just like in the example:

```
import math as m
print(m.sin(m.pi/2))
```

Note: after successful execution of an aliased import, the **original module name becomes inaccessible** and must not be used.

In turn, when you use the `from module import name` variant and you need to change the entity's name, you make an alias for the entity. This will cause the name to be replaced by the alias you choose.

This is how it can be done:

```
from module import name as alias
```

As previously, the original (unaliased) name becomes inaccessible.

The phrase `name as alias` can be repeated - use commas to separate the multiplied phrases, like this:

```
from module import n as a, m as b, o as c
```

The example may look a bit weird, but it works:

```
from math import pi as PI, sin as sine
print(sine(PI/2))
```

Now you're familiar with the basics of using modules. Let us show you some modules and some of their useful entities.