Python Essentials 2:
Module 5
Modules, packages string and list methods, and exceptions

In this module, you will learn about:

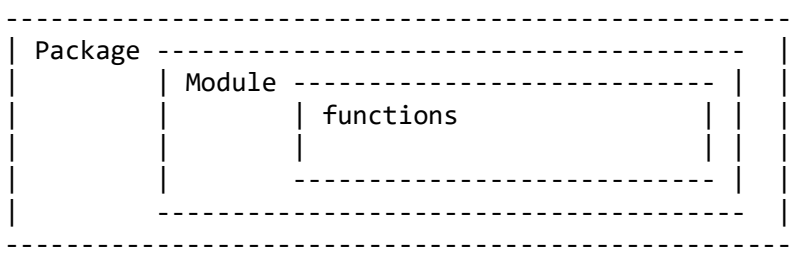
Python modules: their rationale, function, how to import them in different ways, and present the content of some standard modules provided by Python;
the way in which modules are coupled together to make packages.
the concept of an exception and Python's implementation of it, including the try-except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

(part 3)

What is a package?

Writing your own modules doesn't differ much from writing ordinary scripts.

There are some specific aspects you must be aware of, but it definitely isn't rocket science. You'll see this soon enough.



analogous:

packages	folders
modules	files
functions	file contents

Let's summarize some important issues:

a module is a kind of container filled with functions - you can pack as many functions as you want into one module and distribute it across the world;

of course, it's generally a good idea not to mix functions with different application areas within one module (just like in a library - nobody expects scientific works to be put among comic books), so group your functions carefully and name the module containing them in a clear and intuitive way (e.g., don't give the name arcade_games to a module containing functions intended to partition and format hard disks)

making many modules may cause a little mess - sooner or later you'll want to group your modules exactly in the same way as you've previously grouped functions - is there a more general container than a module?

yes, there is - it's a package; in the world of modules, a package plays a similar role to a folder/directory in the world of files.

Your first module: step 1

In this section you're going to be working locally on your machine. Let's start from scratch. Create an empty file, just like this:

Create a module.py file

You will need two files to repeat these experiments. The first of them will be the module itself. It's empty now. Don't worry, you're going to fill it with actual code soon.

We've named the file module.py. Not very creative, but simple and clear.

Your first module: step 2

The second file contains the code using the new module. Its name is main.py. Its content is very brief so far:

Creating a main.py file containing the import module instruction

```
import module
```

main.py

Note: both files have to be located in the same folder. We strongly encourage you to create an empty, new folder for both files. Some things will be easier then.

Launch IDLE (or any other IDE you prefer) and run the main.py file. What do you see?
You should see nothing. This means that Python has successfully imported the contents of the module.py file.
It doesn't matter that the module is empty for now. The very first step has been done, but before you take the next step, we want you to take a look into the folder in which both files exist.

Do you notice something interesting?

A new subfolder has appeared - can you see it? Its name is __pycache__. Take a look inside. What do you see?

There is a file named (more or less) module.cpython-xy.pyc where x and y are digits derived from your version of Python (e.g., they will be 3 and 8 if you use Python 3.8).

The name of the file is the same as your module's name (module here). The part after the first dot says which Python implementation has created the file (CPython here) and its version number. The last part (pyc) comes from the words Python and compiled.

You can look inside the file - the content is completely unreadable to humans. It has to be like that, as the file is intended for Python's use only.
When Python imports a module for the first time, it translates its contents into a somewhat compiled shape.

The file doesn't contain machine code - it's internal Python semi-compiled code, ready to be executed by Python's interpreter. As such a file doesn't require lots of the checks needed for a pure source file, the execution starts faster, and runs faster, too.

Thanks to that, every subsequent import will go quicker than interpreting the source text from scratch.

Python is able to check if the module's source file has been modified (in this case, the pyc file will be rebuilt) or not (when the pyc file may be run at once). As this process is fully automatic and transparent, you don't have to keep it in mind.

Your first module: step 3

Now we've put a little something into the module file:

Updating the module.py file

```
print("I like to be a module.")
```

module.py

Can you notice any differences between a module and an ordinary script? There are none so far.

It's possible to run this file like any other script. Try it for yourself.

What happens? You should see the following line inside your console:

```
I like to be a module.
```
output

Your first module: step 4

Let's go back to the main.py file:

The main.py file containing the import module instruction

```
import module
```

main.py

Run it. What do you see? Hopefully, you see something like this:

```
I like to be a module.
```
output

What does it actually mean?

When a module is imported, its content is implicitly executed by Python. It gives the module the chance to initialize some of its internal aspects (e.g., it may assign some variables with useful values).

Note: the initialization takes place only once, when the first import occurs, so the assignments done by the module aren't repeated unnecessarily.

Imagine the following context:

there is a module named mod1;
there is a module named mod2 which contains the import mod1 instruction;
there is a main file containing the import mod1 and import mod2 instructions.

At first glance, you may think that mod1 will be imported twice - fortunately, only the first import occurs. Python remembers the imported modules and silently omits all subsequent imports.

Your first module: step 5

Python can do much more. It also creates a variable called __name__.

Moreover, each source file uses its own, separate version of the variable - it isn't shared between modules.

We'll show you how to use it. Modify the module a bit:

Updating the module.py file

```
print("I like to be a module.")
print(__name__)
```

module.py

Now run the module.py file. You should see the following lines:

```
I like to be a module
__main__
```
output

Now run the main.py file. And? Do you see the same as us?

```
I like to be a module
module
```
output

We can say that:

- when you run a file directly, its __name__ variable is set to __main__;
- when a file is imported as a module, its __name__ variable is set to the file's name (excluding .py)

Your first module: step 6

This is how you can make use of the __main__ variable in order to detect the context in which your code has been activated:

Updating the module.py file

```
if __name__ == "__main__":
    print("I prefer to be a module.")
else:
    print("I like to be a module.")
```

module.py

There's a cleverer way to utilize the variable, however. If you write a module filled with a number of complex functions, you can use it to place a series of tests to check if the functions work properly.

Each time you modify any of these functions, you can simply run the module to make sure that your amendments didn't spoil the code. These tests will be omitted when the code is imported as a module.

Your first module: step 7

This module will contain two simple functions, and if you want to know how many times the functions have been invoked, you need a counter initialized to zero when the module is being imported.

You can do it this way:

Updating the module.py file

```
counter = 0

if __name__ == "__main__":
    print("I prefer to be a module.")
else:
    print("I like to be a module.")
```

module.py

Your first module: step 8

Introducing such a variable is absolutely correct, but may cause important side effects that you must be aware of.

Take a look at the modified main.py file:

Updating the main.py file

```
import module
print(module.counter)
```

main.py

As you can see, the main file tries to access the module's counter variable. Is this legal? Yes, it is. Is it usable? It may be very usable. Is it safe?

That depends - if you trust your module's users, there's no problem; however, you may not want the rest of the world to see your personal/private variable.

Unlike many other programming languages, Python has no means of allowing you to hide such variables from the eyes of the module's users.

You can only inform your users that this is your variable, that they may read it, but that they should not modify it under any circumstances.

This is done by preceding the variable's name with _ (one underscore) or __ (two underscores), but remember, it's only a convention. Your module's users may obey it or they may not.

Of course, we'll follow the convention. Now let's put two functions into the module - they'll evaluate the sum and product of the numbers collected in a list.

In addition, let's add some ornaments there and remove any superfluous remnants.

Your first module: step 9

Okay. Let's write some brand new code in our module.py file. The updated module is ready here:

```
#!/usr/bin/env python3

""" module.py - an example of a Python module """

__counter = 0


def suml(the_list):
    global __counter
    __counter += 1
    the_sum = 0
    for element in the_list:
        the_sum += element
    return the_sum


def prodl(the_list):
    global __counter
    __counter += 1
    prod = 1
    for element in the_list:
        prod *= element
    return prod


if __name__ == "__main__":
    print("I prefer to be a module, but I can do some tests for you.")
    my_list = [i+1 for i in range(5)]
    print(suml(my_list) == 15)
    print(prodl(my_list) == 120)
```

module.py

A few elements need some explanation, we think:

the line starting with #! has many names - it may be called shabang, shebang, hashbang, poundbang or even hashpling (don't ask us why). The name itself means nothing here - its role is more important. From Python's point of view, it's just a comment as it starts with #. For Unix and Unix-like OSs (including MacOS) such a line instructs the OS how to execute the contents of the file (in other words, what program needs to be launched to interpret the text). In some environments (especially those connected with web servers) the absence of that line will cause trouble;

a string (maybe a multiline) placed before any module instructions (including imports) is called the doc-string, and should briefly explain the purpose and contents of the module;

the functions defined inside the module (suml() and prodl()) are available for import;

we've used the __name__ variable to detect when the file is run stand-alone, and seized this opportunity to perform some simple tests.

Your first module: step 10

Now it's possible to use the updated module - this is one way:

Updating the main.py file

```
from module import suml, prodl

zeroes = [0 for i in range(5)]
ones = [1 for i in range(5)]
print(suml(zeroes))
print(prodl(ones))
```

main.py

Your first module: step 11

It's time to make our example more complicated - so far we've assumed that the main Python file is located in the same folder/directory as the module to be imported.

Let's give up this assumption and conduct the following thought experiment:

> we are using Windows ® OS (this assumption is important, as the file name's shape depends on it)
> the main Python script lies in C:\Users\user\py\progs and is named main.py
> the module to import is located in C:\Users\user\py\modules

How Python seeks modules - modules access tree

How to deal with it?

To answer this question, we have to talk about how Python searches for modules. There's a special variable (actually a list) storing all locations (folders/directories) that are searched in order to find a module which has been requested by the import instruction.

Python browses these folders in the order in which they are listed in the list - if the module cannot be found in any of these directories, the import fails.

Otherwise, the first folder containing a module with the desired name will be taken into consideration (if any of the remaining folders contains a module of that name, it will be ignored).

The variable is named path, and it's accessible through the module named sys. This is how you can check its regular value:

```
import sys

for p in sys.path:
    print(p)
```

We've launched the code inside the C:\User\user folder, and this is what we've got:

```
C:\Users\user
C:\Users\user\AppData\Local\Programs\Python\Python36-32\python36.zip
C:\Users\user\AppData\Local\Programs\Python\Python36-32\DLLs
```

C:\Users\user\AppData\Local\Programs\Python\Python36-32\lib
C:\Users\user\AppData\Local\Programs\Python\Python36-32
C:\Users\user\AppData\Local\Programs\Python\Python36-32\lib\site-packages
sample output

Note: the folder in which the execution starts is listed in the first path's element.

Note once again: there is a zip file listed as one of the path's elements - it's not an error. Python is able to treat zip files as ordinary folders - this can save lots of storage.

Can you figure out how we can solve our problem now? We can add a folder containing the module to the path variable (it's fully modifiable).

Your first module: step 12

One of several possible solutions looks like this:

Updating the main.py file with path.append('..\\modules')

```
from sys import path

path.append('..\\modules')

import module

zeroes = [0 for i in range(5)]
ones = [1 for i in range(5)]
print(module.suml(zeroes))
print(module.prodl(ones))
```

main.py

Note:

we've doubled the \ inside folder name - do you know why?

Check
we've used the relative name of the folder - this will work if you start the main.py file directly from its home folder, and won't work if the current directory doesn't fit the relative path; you can always use an absolute path, like this:

```
path.append('C:\\Users\\user\\py\\modules')
```

we've used the append() method - in effect, the new path will occupy the last element in the path list; if you don't like the idea, you can use insert() instead.

Your first package: step 1

Imagine that in the not-so-distant future you and your associates write a large number of Python functions.

Your team decides to group the functions in separate modules, and this is the final result of the ordering:

```
#! /usr/bin/env python3

""" module: alpha """

def funA():
   return "Alpha"

if __name__ == "__main__":
   print("I prefer to be a module.")
```

alpha.py

```
def funB():...
```

beta.py

```
def funI():...
```

iota.py

```
def funS():...
```

sigma.py

```
def funT():...
```

tau.py

```
def funP():...
```

psi.py

```
def funO():...
```

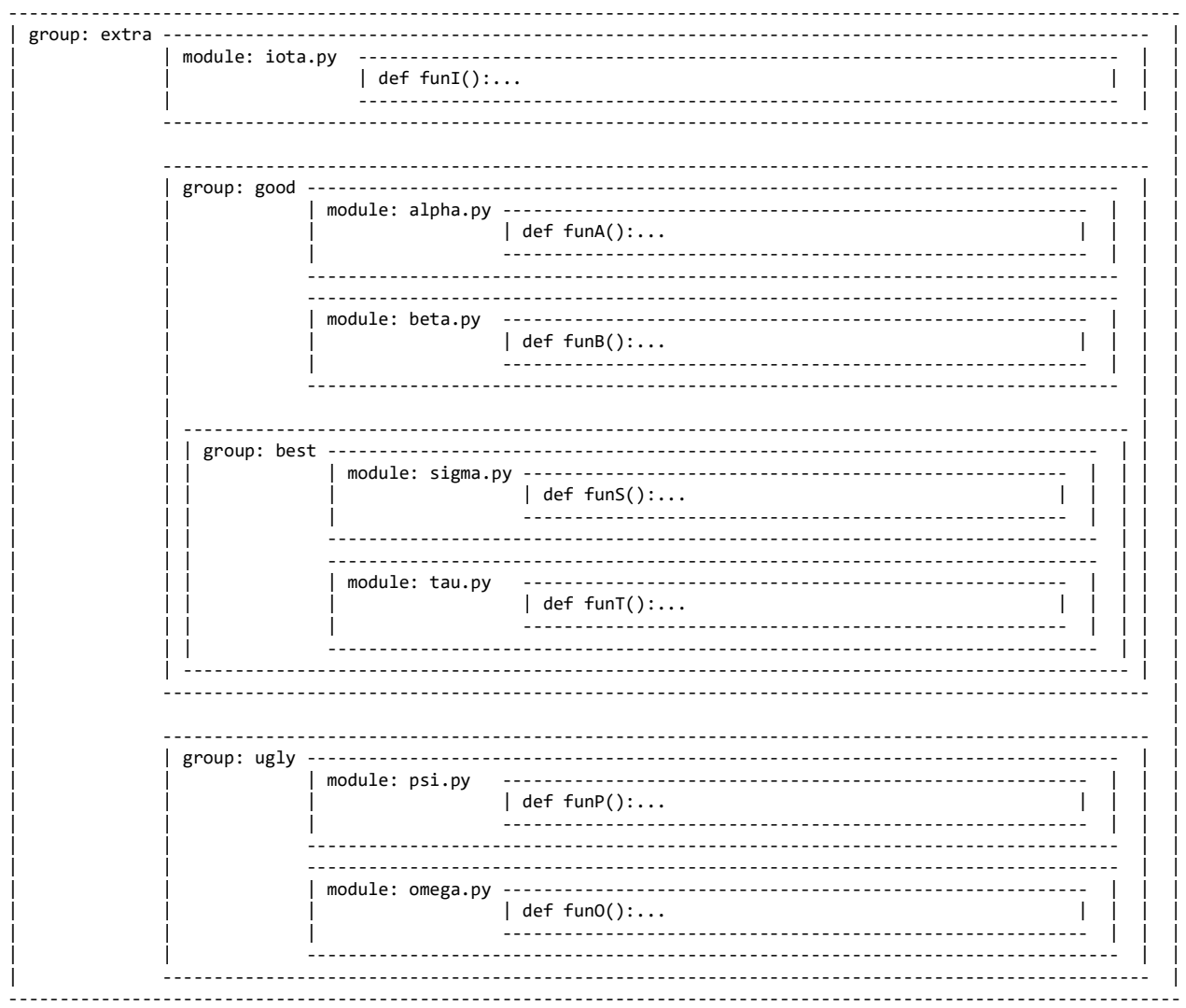
omega.py

Note: we've presented the whole content for the alpha.py module only - assume that all the modules look similar (they contain one function named funX, where X is the first letter of the module's name).

Your first package: step 2

Suddenly, somebody notices that these modules form their own hierarchy, so putting them all in a flat structure won't be a good idea.

After some discussion, the team comes to the conclusion that the modules have to be grouped. All participants agree that the following tree structure perfectly reflects the mutual relationships between the modules:



Let's review this from the bottom up:

the ugly group contains two modules: psi and omega;
the best group contains two modules: sigma and tau;
the good group contains two modules (alpha and beta) and one subgroup (best)
the extra group contains two subgroups (good and ugly) and one module (iota)

Does it look bad? Not at all - analyze the structure carefully. It resembles something, doesn't it?

It looks like a directory structure.

Let's build a tree reflecting projected dependencies between the modules.

Your first package: step 3

This is how the tree currently looks:

```
project
| --packages
|   |--extra
|       |--iota.py
|       |--good
|       |  |--alpha.py
|       |  |--beta.py
|       |  |--best
|       |     |--sigma.py
|       |     |--tau.py
|       |--ugly
|           |--omega.py
|           |--psi.py
|--progs
    |--main.py
```

Such a structure is almost a package (in the Python sense). It lacks the fine detail to be both functional and operative. We'll complete it in a moment.

If you assume that extra is the name of a newly created package (think of it as the package's root), it will impose a naming rule which allows you to clearly name every entity from the tree.

For example:

the location of a function named funT() from the tau package may be described as:

extra.good.best.tau.funT()

a function marked as:

extra.ugly.psi.funP()

comes from the psi module being stored in the ugly subpackage of the extra package.

Your first package: step 4

There are two questions to answer:

how do you transform such a tree (actually, a subtree) into a real Python package (in other words, how do you convince Python that such a tree is not just a bunch of junk files, but a set of modules)?

where do you put the subtree to make it accessible to Python?

The first question has a surprising answer: packages, like modules, may require initialization.

The initialization of a module is done by an unbound code (not a part of any function) located inside the module's file. As a package is not a file, this technique is useless for initializing packages.

You need to use a different trick instead - Python expects that there is a file with a very unique name inside the package's folder: __init__.py.

The content of the file is executed when any of the package's modules is imported. If you don't want any special initializations, you can leave the file empty, but you mustn't omit it.

Your first package: step 5

Remember: the presence of the __init.py__ file finally makes up the package.

Note: it's not only the root folder that can contain __init.py__ file - you can put it inside any of its subfolders (subpackages) too. It may be useful if some of the subpackages require individual treatment and special kinds of initialization.

Now it's time to answer the second question - the answer is simple: anywhere. You only have to ensure that Python is aware of the package's location. You already know how to do that.

You're ready to make use of your first package.

Your first package: step 6

Let's assume that the working environment looks as follows:

We've prepared a zip file containing all the files from the packages branch. You can download it and use it for your own experiments, but remember to unpack it in the folder presented in the scheme, otherwise, it won't be accessible to the code from the main file.

DOWNLOAD Modules and Packages ZIP file
[https://edube.org/uploads/media/default/0001/01/39a03067f85a9b39c0c94ca50b5d445b7df18a04.zip]

You'll be continuing your experiments using the main2.py file.

Your first package: step 7

We are going to access the funI() function from the iota module from the top of the extra package. It forces us to use qualified package names (associate this with naming folders and subfolders - the conventions are very similar).

This is how to do it:

```
from sys import path
path.append('..\\packages')

import extra.iota
print(extra.iota.funI())
```

main2.py

Note:

- we've modified the path variable to make it accessible to Python;
- the import doesn't point directly to the module, but specifies the fully qualified path from the top of the package;
- replacing import extra.iota with import iota will cause an error.

The following variant is valid too:

The main2.py file alternative version

```
from sys import path
path.append('..\\packages')

from extra.iota import funI
print(funI())
```

main2.py

Note the qualified name of the iota module.

Your first package: step 8

Now let's reach all the way to the bottom of the tree - this is how to get access to the sigma and tau modules:

The main2.py file

```
from sys import path

path.append('..\\packages')

import extra.good.best.sigma
from extra.good.best.tau import funT

print(extra.good.best.sigma.funS())
print(funT())
```

main2.py

You can make your life easier by using aliasing:

```
from sys import path

path.append('..\\packages')

import extra.good.best.sigma as sig
import extra.good.alpha as alp

print(sig.funS())
print(alp.funA())
```

main2.py

Your first package: step 9

Let's assume that we've zipped the whole subdirectory, starting from the extra folder (including it), and let's get a file named extrapack.zip. Next, we put the file inside the packages folder.

Now we are able to use the zip file in a role of packages:

```
from sys import path

path.append('..\\packages\\extrapack.zip')

import extra.good.best.sigma as sig
import extra.good.alpha as alp
from extra.iota import funI
from extra.good.beta import funB

print(sig.funS())
print(alp.funA())
print(funI())
print(funB())
```

main2.py

If you want to conduct your own experiments with the package we've created, you can download it below. We encourage you to do so.

DOWNLOAD Extrapack ZIP file
[https://edube.org/uploads/media/default/0001/01/d9df38daa0410952c4cbf85b47892954c45b9215.zip]

Now you can create modules and combine them into packages. It's time to start a completely different discussion - about errors, failures and crashes.

Key takeaways

1. While a module is designed to couple together some related entities (functions, variables, constants, etc.), a package is a container which enables the coupling of several related modules under one common name. Such a container can be distributed as-is (as a batch of files deployed in a directory sub-tree) or it can be packed inside a zip file.

2. During the very first import of the actual module, Python translates its source code into the semi-compiled format stored inside the pyc files, and deploys these files into the __pycache__ directory located in the module's home directory.

3. If you want to instruct your module's user that a particular entity should be treated as private (i.e. not to be explicitly used outside the module) you can mark its name with either the _ or __ prefix. Don't forget that this is only a recommendation, not an order.

4. The names shabang, shebang, hasbang, poundbang, and hashpling describe the digraph written as #!, used to instruct Unix-like OSs how the Python source file should be launched. This convention has no effect under MS Windows.

5. If you want convince Python that it should take into account a non-standard package's directory, its name needs to be inserted/appended into/to the import directory list stored in the path variable contained in the sys module.

6. A Python file named __init__.py is implicitly run when a package containing it is subject to import, and is used to initialize a package and/or its sub-packages (if any). The file may be empty, but must not be absent.

Exercise 1

You want to prevent your module's user from running your code as an ordinary script. How will you achieve such an effect?

Exercise 2

Some additional and necessary packages are stored inside the D:\Python\Project\Modules directory. Write a code ensuring that the directory is traversed by Python in order to find all requested modules.

Exercise 3

The directory mentioned in the previous exercise contains a sub-tree of the following structure:

```
abc
 |__ def
    |__ mymodule.py
```

Assuming that D:\Python\Project\Modules has been successfully appended to the sys.path list, write an import directive letting you use all the mymodule entities.