Learn Python Programming - 3rd Edition - Packt

1. A Gentle Introduction to Python

- **A proper introduction:**
    - ◇ The two main features any object has ar eproperties and methods.
        - ▪ **Properties**: are characteristics of an object.
        - ▪ **Methods**: are things an object can do.

    ◇ Object expose **methods** and that can be run and properties that you can inspect.

    ◇ According to the data model documentation on the official Python documentation:
    ▪ “**Object's are Python's abstraction for data. All data in a Python program is represented by objects or by relations between objects.**”
    - https://docs.python.org/3/reference/datamodel.html

    ◇ For now all we need to know is that **every object in Python has an ID (or identity). a type, and a value**.

    ◇ Once created, the ID of an object is never changed. It's a unique identifier for it, and it's used behind the scenes by Python to retrieve the object when we want to use it. The type also never changes. The types states what operations are supported by the object and the possible values that can be assigned to it. The value of data can be changed or not: if it can, the object is said to be **mutable**, otherwise, it is said to be **immutable**.

    ◇ An important aspect of Python is its intrisic multiparadigm nature. You can use it as a scripting language, but you can also exploit object-oriented, imperative, and functional programming styles, it is extremely versatile.

- **About Virtual Environments:**
    ◇ When working with Python it is very common to use **virtual environments**. Let's see what they are and why we need them by means of a simple example:
    ▪ You install Python on your system and you start working on a website for . You create a project folder and start coding. Along the way, you also install some libraries; for example the Django framework, let's say the Django version you install for **Project X** is **2.2**.
    ▪ Now, your website is so good that you get another client, **Y**. This person wants you to build another website, so you start **Project Y** and, along the way, you need to install Django again. The only issue is that now the Django version is 3.0 and you cannot install it on your system because this would replace the version you installed for **Project X**. You don't want to risk introducing incompatibility issues, so you have two options: you either stick with the version you have currently on your machine, or you upgrade it and make sure the first project is still fullt working with the new version.

    ◇ Virtual environments are isolated Python environments, each of which is a folder that contains all the necessary executables to use the packages that a Python project would need.

◇ So, you create a virtual environment for Project X, install all the dependencies, and then you create a virtual environment for Project X, installing all its dependencies, without the slightiest worry that because every library you install ends up within the boundaries of the appropriate virtual environment. In our example, Project X will hold Django 2.2, while Project Y will hold Django 3.0.

◇ **Note:**

▪ It is of vital importance that you never install libraries at the system level. Linux for example, relies on Python for many different tasks and operations, and if you fiddle with the system installation of Python, you risk compromising the integrity of the whole system.

▪ So, take this as a rule, such as brushing your teeth, before going to bed:

- **always create a virtual environment when starting a new project.**

◇ When it comes to creating a virtual environment on your system, there are a few different methods to carry this out. As of **Python 3.5**, the suggested way to create a virtual environment is to use the venv module. You can look it up on the official documentation page for more information:

▪ https://docs.python.org/3/library/venv.html

==

◇ **Creating virtual environments:**

1- First go to the directory where you wish to create the project

2- Second create a virtual environment with whatever name you want:

- Execute the **venv** command:

→

```
python3 -m venv <virtual_environment_name>
```

3- Then we have to activate the virtual environment (do this on powershell):

-
```
<virtual_environment_name>\Scripts\activate
```

4- Now run:

-
```
where python
```

→ and it should give you the environments Python directory.

5- Now type ' **Python** ' (without quotes) in the console and it should enter Python mode.

6- You can use **exit()** to exit the Python environment.

7- Use **deactivate** to deactivate the environment.

==

• **Installing third-party libraries**:

◇ In order to install third-party libraries, we need to use the Python Package Installer, known as **pip**.

◇ You use the following command to install third-party libraries taken from a **requirements** file:

▪ `pip install -r requirements.txt`

• **How is Python code organized**:

◇ Python gives you a structure, called a **package**, which allows you to group modules together. A package is nothing more than a folder that must contain a special file:

▪ **__init__.py**

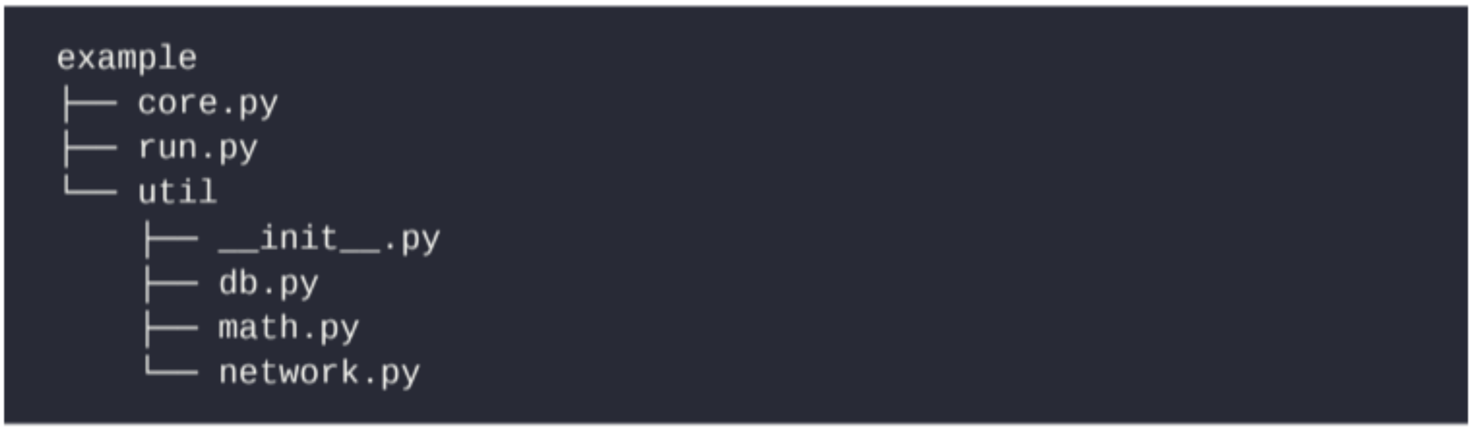
- This does not need to hold any code, but its presence is required to tell Python that this is not just a typical folder - it is actually a large package.

◇ Here's an example of how the **example** directory would look like:

▪ first we issue the following command:

- `tree example`

→



```
example
├── core.py
├── run.py
└── util
    ├── __init__.py
    ├── db.py
    ├── math.py
    └── network.py
```

⇒ Within the root of this example we have two modules, **core.py** and **run.py**, and one package, **util**.

• Within **core.py** there may be the core logic of our application.

• Within the **run.py** module we can probably find the the logic to start the application.

• In the **util** package we can find various utility tools, we can guess that the modules there are named based on the type of tools they hold.

• **How do we use modules and packages:**

◇ We basically use a bunch of functions so we don't repeat code.

◇ In the previous example:

▪ the package **util** is our **utility library**. This is our custom belt that holds all those reusable tools (that is, functions), which we need in our application. Some of them will use things that are out of the scope of Python's standard library, so we have to code them ourselves.

• **Python's Execution Model**:

◇ **Names and namespaces:**

▪ **Python names** are are the closest abstraction to what other languages call **variables**. **Names** basically refer to objects and are introduced by **name-binding** operations.

- Let's see a quick example:

→

```
>>> n = 3  # integer number
>>> address = "221b Baker Street, NW1 6XE, London"  # Sherlock Holm
es' address
>>> employee = {
...     'age': 45,
...     'role': 'CTO',
...     'SSN': 'AB1234567',
... }
>>> # let's print them
>>> n
3
>>> address
'221b Baker Street, NW1 6XE, London'
>>> employee
{'age': 45, 'role': 'CTO', 'SSN': 'AB1234567'}
>>> other_name
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'other_name' is not defined
>>>
```

⇒ Remember that each Python object has an **identity**, a **type**, and a **value**. We defined three objects in the preceding code; let's now examine their type and values:

• An **integer** number **n (type: int**, **value: 3**)

• A **string address** (**type: str**, **value: Sherlock Holmes' address**)

• A **dictionary employee** (**type: dict**, **value: a dictionary object with three key/value pairs**).

◇ The previous objects are **names**:

▪ these can be used to retrieve data from within our code. They need to be kept somewhere so that whenever we need to retrieve those objects, we can use their names to fectch them. We need some space to hold them, hence the name: **namespaces**.

▪ **Namespaces**: is a mapping **from names to objects**. Examples are the set of builtin names (containing functions that are always accesible in any Python program), the global names in a module, and the local names in a function. Even the set of attributes of an object can be considered a namespace.

- Namespaces allow you to define and organize your names with clarity, without overlapping or interference. For example, the namespace associated with the book we were looking for (in a previous example) in the library can be used to import the book itself, like this:

→

```
from library.second_floor.section_X.row_three import book
```

⇒ We start from the library namespace, and by means of the dot (**.**) operator, we walk into that namespace. Within this namespace, we look for **second_floor**, and again we walk into it with the **.** operator. We then walk into **section_x**, and finally, within the last namespace, **row_three**, we find the name we were looking for: **book**.

▪ There is another concept, closely related tot hat of a namespace, which we're gonnas see briefly: **scope**:

- The order in which the namespaces are scanned when looking for a name is **local**, **enclosing**, **global**, **built-in** (**LEGB**).

• **Basically everything in Python is an object, so they deserve a bit more attention**:

◇ Most of what you will ever do, in Python, has to do with manipulating objects.

◇ We have already seen that objects are Python's abstraction for data. In fact, everything in Python is an object: numbers, strings (data structures that hold text), containers, collections, even functions. You can think of them as if they were boxes with at least three features: an ID (which is unique), a type, and a value.

▪ But how do they come to life? How do we create them? How do we write our own custom objects? The answer lies in one simple word: **classes**.

▪ Objects are, in fact, instances of classes. The beauty of Python is that classes are objects themselves, but let's not go down this road. it leads to one of the most advanced concepts of this language: **metaclasses**.

◇ **Classes**: an abstract set of features and characteristics that together form something.

▪ Classes are used to create objects.

- When you have your own bike, it's an instance of the bike class. Your bike is an object with its own characteristics and methods. You have your own bike, same class, but different instance. Every bike ever created in the world is an instance of the bike class.

- Let's see an example. We will write a class that defines a bike and create two bikes, one red and one blue:

→

```
# Let's define the class Bike
class Bike:
    def __init__(self, color, frame_material):
        self.color = color
        self.frame_material = frame_material
    def brake(self):
        print("Braking!")

# Let's create a couple instances
red_bike = Bike('Red', 'Carbon fiber')
blue_bike = Bike('Blue', 'Steel')

#Let's inspect the objects we have, instances of the Bike class
print(red_bike.color) # prints: red
print(red_bike.frame_material) # prints: Carbon fiber
print(blue_bike.color) # prints: Blue
print(blue_bike.frame_material) # prints: Steel

#Let's brake
red_bike.brake() # prints: Braking!
```

⇒ The first **method**:

- **__init__**

◇ is an **initializer**. It usessome Python magic to set up the objects with the values we pass when we create.

◇ **Note:** every method that has leading and trailing underscores, in Python, is called a **magic method**. **Magic methods are used by Python for a multitude of different pureposes**, hence it's never a good idea to name a custom method using two leading and trailing underscores.

- **Guidelines for writing good code (according to PEP 8 →** https://peps.python.org/pep-0008/**):**

◇ **Maximum Line Length:**

▪ Limit all line to a maximum of 79 characters.

- for documentation strings or comments, the line length should be limited to 72 characters.

◇ **Should a Line Break Before or After a Binary Operator**:

▪

```
# Wrong:
# operators sit far away from their operands
income = (gross_wages +
          taxable_interest +
          (dividends - qualified_dividends) -
          ira_deduction -
          student_loan_interest)


# Correct:
# easy to match operators with operands
income = (gross_wages
          + taxable_interest
          + (dividends - qualified_dividends)
          - ira_deduction
          - student_loan_interest)
```

◇ **Source File Encoding**:

▪ In the standard library, non-UTF-8 encondings should be used only for test purposes. Use non-ASCII characters sparingly, preferably only to denote palce and human names. If using non-ASCII characters as data, avoid noisy Unicode characters like zalgo, and byte order marks.

◇ **Imports**:

▪ Imports should usually be on separate lines:

-
```
# Correct:
import os
import sys

# Wrong:
import sys, os
```

- It's okay to say this though:
  →

```
# Correct:
from subprocess import Popen, PIPE
```

▪ Imports should be grouped in the following order:

1> Standard library imports.

2> Related third party imports.

3> Local application/library specific imports.

▪ You should put a blank line between each group of imports.

▪ Absolute imports are recommended, as they are usually more readable and tend to be better behaved (or at least give better error messages) if the import systemis incorrectly configured (such as when a directory inside a package ends up on **sys.path**):

-
```
import mypkg.sibling
from mypkg import sibling
from mypkg.sibling import example
```

▪ Wildcard imports (**from <module> import** *) should be avoided, as they make it unclear which names are present in the namesapace, confusing both readers and many automated tools.

◇ **Module Level Dunder Names**:

▪ Module level "dunders" (i.e. names with two leading and two trailing underscores) such as:

- __all__
- __author__
- __version__
- etc.

▪ should be placed after the module docstring but before any import statements except from **__future__** imports. Python mandates that future-imports mist appear in the module before any other code except document ation strings:

-
```
"""This is the example module.

This module does stuff.
"""

from __future__ import barry_as_FLUFL

__all__ = ['a', 'b', 'c']
```

```
__version__ = '0.1'
__author__ = 'Cardinal Biggles'

import os
import sys
```

◇ **When to Use Trailing Commas**:

▪ When trailing commasa are redundant, they are often helpful when a version controls system is used, when a list of values,a rguments, or imported items is expected to be extended over time. The pattern is to put each value (etc.) on a line by itself, always adding a trailing comma, and add the close parenthesis/bracket/brace on the next line. However it does not make sense to have a trailing comma on the same line as the closing delimiter:

```
# Correct:
FILES = [
    'setup.cfg',
    'tox.ini',
    ]
initialize(FILES,
           error=True,
           )
# Wrong:
FILES = ['setup.cfg', 'tox.ini',]
initialize(FILES, error=True,)
```

-

◇ **Comments**:

▪ You should use two spaces after a sentece - ending period in multi-sentence comments, except after the final sentence.

▪ Python coders from non-English speaking countries: plase write your comments in English, unless you are 120% sure the code will never be read by people who don't speak your language.

◇ **Naming Conventions:**

▪ The naming conventions of Python's library are a bit of a mess, so we'll never get this completely consistent - nevertheless, here are the currently recommended naming standards:

- **Descriptive: Naming Styles**:

→ **Note:** When using acronyms in **CapitalizedWords**, capitalize all the letters of the acronym. thus **HTTPServerError** is better than **HttpServerError**.

▪ **Prescriptive: Naming Conventions:**

- **Names to avoid**: Never use the characters 'l' (lowercase letter el), 'O' (uppercase letter oh), or 'I' (uppercase letter eye) as single character variable names. In some fonts, these characters are indistingushable from the numeral one and zero, when tempted to use 'l', use 'L' instead.

▪ **Package and Module Names:**

- Modules should have short, all-lowercase names. underscores can be used in the module name if it improves readibility. Python packages should also have short, all-lowercase names, although the use of underscores is discouraged.

- When an extension modules written in C or C++ has an accompanying Python module that provides a higher level (e.g. more object oriented) interface, the C/C++ module has a leading underscore (e.g. **_socket**)

▪ **Class Names**:
- Class names should normally use the **CapWords** convention.

▪ **Type Variable Names:**
- Names of type variable introduced in PEP 484 should normally use CapWords preferring short names: **T**, **AnyString**, **Num**.

▪ **Exception Names:**
- Because exception should be classes, the class naming convention applies here. However, you should use the suffix "Error" on your exception names (if the exception actually is an error).

▪ **Global Variable Names**:
- The conventions are about the same as those for functions.
- Modules that are designed for use via **from M import *** should use the **__all__** mechanism to prevent exporting globals, or use the oler convention of prefixing such globals with an underscore (which you might want to do indicate these globals are "module non-public").

▪ **Function and Variable Names**:
- Function names should be lowercase, with words separated by underscores as necessary to improve readability.
- Variable names follow the same convention as function names.

▪ **Function and Method Arguments**:
- Always use **self** for the first argument to instace methods.
- Always use **cls** for the first argument to class methods.
- If a function argument´s name clashes with a reserved keyword, it is generally better to append a single trailing underscore rather than use an abbreviation or spelling corruption. Thus **_class** is better than **clss**. (Perhaps better is to avoid such classes by using a synonym).

▪ **Method Names and Instance Variables:**
- Use the function naming rules: lowercase with words separated by underscores as necessary to improve readibility.
- Use one leading underscore for non-public methods and instance variables.
- To avoid name clashes with subclasses, use two leading underscores to invoke Python's names mangling rules.
- Python mangles these names with the class name: if class Foo has an attribure names **__a**, it cannot be accessed by **Foo.__a** (an insistent user could still gain access by calling **Foo._Foo_a**). Generally double leading underscores should be used only to avoid name conflicts with attributes in classes designed to be subclassed.
- **Note**: there is some controversy about the use of **__names**

▪ **Constants**:

- Constants are usually defined on a module level and written in all capital letters with underscores separating words. Examples include:

→ MAX_OVERFLOW

→ TOTAL

▪ **Designing for Inheritance:**

- Always decide whether a class's methods and instance variables (collectively: "attributes") should be public or non-public. If in doubt, choose non-public; It's easier to make it public later than to make a public attribute non-public.

- We don't use the term "private" here, since no attribute is really private in Python (without a generally necessary amount of work).

◇ **Programming Recommendations:**

▪ Use **is not** operator rather than **not ... is**. While both expressions are functionally identical, the former is more readable and preferred:

-
```
# Correct:
if foo is not None:
# Wrong:
if not foo is None:
```

▪ When implementing ordering operations with rich comparisons, it is best to implement all six operations (__eq__, __ne__, __lt__, __le__, __gt__, __ge__)
rather than relying on other code to only exercise a particular comparison.

▪ Always use a def statement instead of an assignment statement that binds a lambda expression directly to an identifier:

-
```
# Correct:
def f(x): return 2*x

# Wrong:
f = lambda x: 2*x
```

▪ When catching exceptions, mention specifc exceptions whenever possible instead of using a bare **except**: class:

-
```
try:
    import platform_specific_module
except ImportError:
    platform_specific_module = None
```

→ a bare **except:** clause will catch **SystemExit** and **KeyboardInterrupt** exceptions, making it harder to interrupt a program with Control+C, and can disguise other problems. If you want to catch all exceptions that signal program errors, use **except Exception:** (bare **except** is equivalent to **except BaseException:**).

▪ Additionally, for all try/except clauses, limit the **try** clause to the absolute minimum amound of code necesary. Again, this avoids masking bugs:

-

```
# Correct:
try:
    value = collection[key]
except KeyError:
    return key_not_found(key)
else:
    return handle_value(value)
# Wrong:
try:
    # Too broad!
    return handle_value(collection[key])
except KeyError:
    # Will also catch KeyError raised by handle_value()
    return key_not_found(key)
```

▪ When a resource is local to a particular section of code, use a **with** statement to ensure it is cleaned up promptly and reliably after use. A **try/finally** statement is also acceptable.

▪ Context managers should be invoked through separate functions or methods whenever they do something other than acquire and release resources:

```
# Correct:
with conn.begin_transaction():
    do_stuff_in_transaction(conn)
# Wrong:
with conn:
    do_stuff_in_transaction(conn)
```

-

→ the latter example doesn't provide information to indicate that the **__enter__** and **__exit__** methods are doing something other than closing the connection after a transaction. Being explicit is important in this case

▪ Be consistent in return statements. Either all return statements in a function should return an expression, or none of them should. If any return statement returns an expression, or none of them should. If any return statement returns an expression, any return statements where noe value is returned should explicitly state this as their **return None**, and an explicit return statement should be present at the end of the function (if reachable.):

```
# Correct:

def foo(x):
    if x >= 0:
        return math.sqrt(x)
    else:
        return None

def bar(x):
    if x < 0:
```

-

```
        return None
    return math.sqrt(x)
# Wrong:

def foo(x):
    if x >= 0:
        return math.sqrt(x)

def bar(x):
    if x < 0:
        return
    return math.sqrt(x)
```

- Use ' '.**startswith()** and ' '**endswith()** instead of string slicing to check for prefixes or suffixes:
  - ' '.**startswith()** and ' '**endswith()** are cleaner and less error prone:

    →

```
# Correct:
if foo.startswith('bar'):
# Wrong:
if foo[:3] == 'bar':
```

- Object type comaprisson should alwatts use **isinstance()** instead of comparing types directly:
  -
```
# Correct:
if isinstance(obj, int):
# Wrong:
if type(obj) is type(1):
```

- For sequence, (strings, lists, tuples), use the fact that empty sequences are false:
  -
```
# Correct:
if not seq:
if seq:

# Wrong:
if len(seq):
if not len(seq):
```

- Don't compare boolean values to True or False using ==:
  -
```
# Correct:
if greeting:

# Wrong:
if greeting == True:
```

    → Worse:

  -
```
# Wrong:
if greeting is True:
```

- Use the flow control statements **return/break/continue** within the finally suite of a **try...finally**, where the flow control statements would jump outside the finally suite, is discouraged. This is because such statements will implicitly cancel any active exception that is propagating through the finally suite:

-
```
# Wrong:
def foo():
    try:
        1 / 0
    finally:
        return 42
```

2. Built-In Data Types

- In this chapter we are going to cover the following:
  - ◇ Python's **objects' structures**.
  - ◇ **Mutability** and **inmutability**.
  - ◇ **Built-in data types**: **numbers**, **strings**, **dates** and **times**, **sequences**, **collection**, and **mapping types**.
  - ◇ The **collection** module.
  - ◇ **Enumerations**.

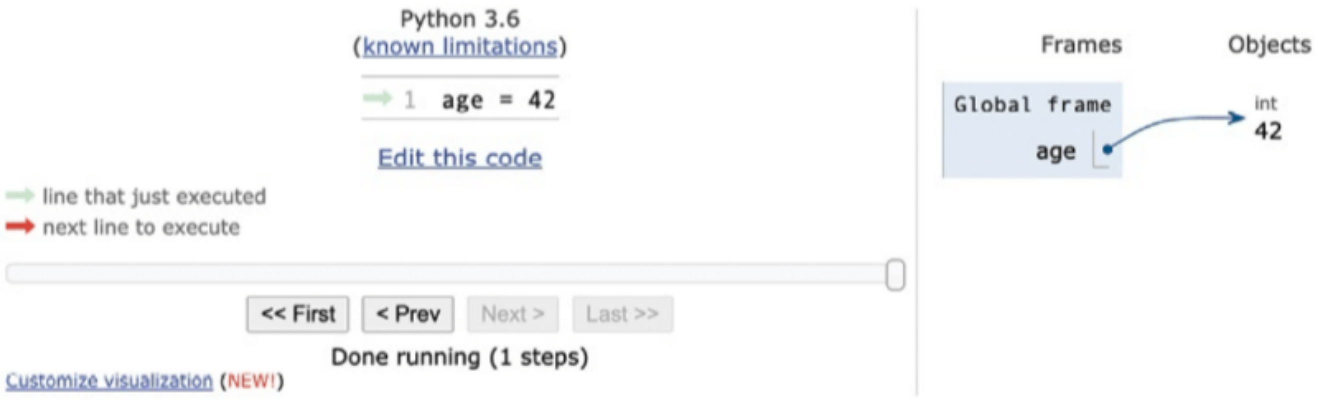
2.1 Everything is an object

• What really happens when you type an instruction like **age = 42** in a Python module.

• So, what happens is that an **object** is created. It gets an **id**, the **type** is set to **int**, and the **value** to **42**. A **name**, **age**, **is placed in the global namespace**, pointing to that object. Therefore, whenever we are in the **global namespace**, after the execution of that line, we can retrieve that object by simply accessing it through its name **age**.

• If you were to move house, you would put all the knives, forks, and spoons in a box and label it cutlery. This is exactly the same concept. Here is a screenshot of what it may look like:

◇



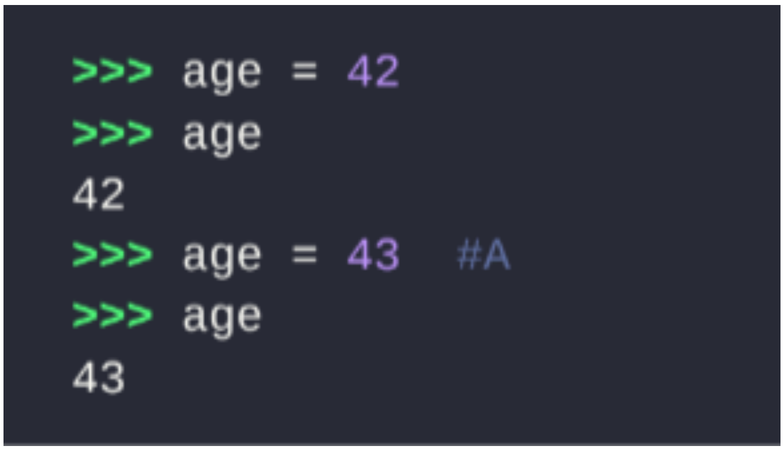
```
age = 42
```

• So, for the rest of this chapter, whenever you read something such as **name = some_value**, think of a name placed in the namespace that is tied to the scope in which the instruction was written, with a nice arrow pointing to an object that has an **id**, a **type**, and a **value**.

2.2 Mutable or inmutable? That is the question

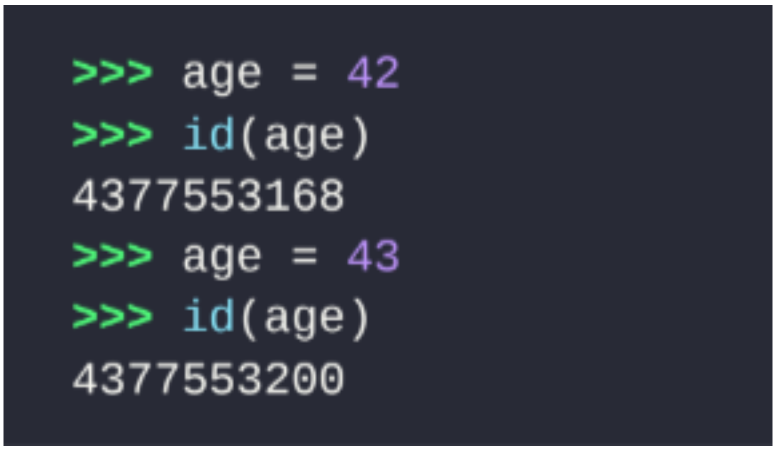
- The first fundamental distinction that Python makes on data is about whether or not the value of an object can change. **If the value can change**, the object is called **mutable**, whereas **if the value cannot change**, the object is called **immutable**.

- It is very important that you understand the distinction between **mutable** and **immutable** because it affects the code you write; take this example:

  ◇ 

```
>>> age = 42
>>> age
42
>>> age = 43  #A
>>> age
43
```

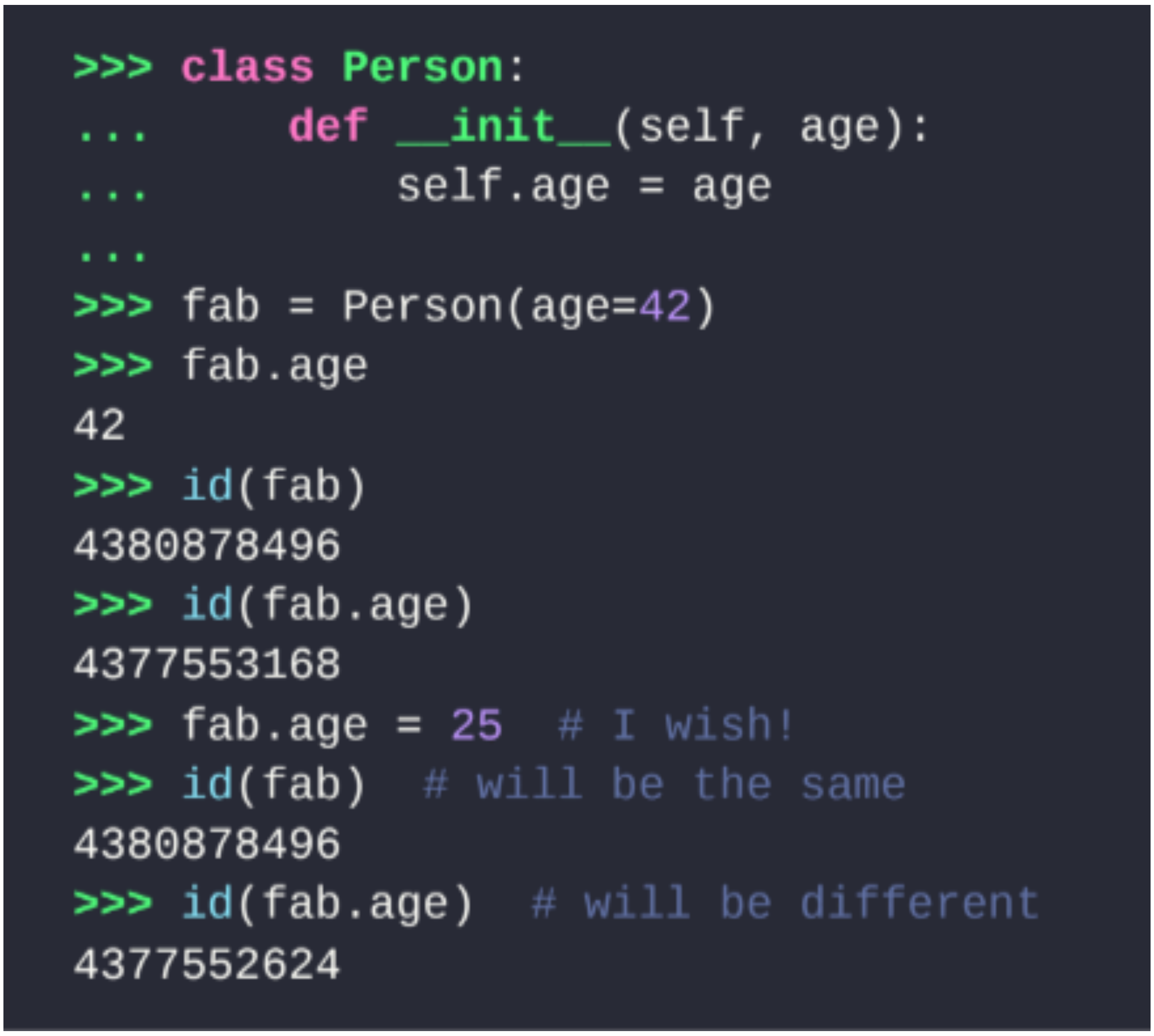
    ▪ In the preceding code, on line **#A**, have we changed the value of **age**? Well, no. But now it's **4 3**. Yes, it's 43, **but 42 was an integer number, of the type int, which is immutable**. So, what happened is really that on the first line, **age** is a name that is set to point to an **int** object, whose value is **42**. When we type **age = 43**, what happens is that another object is created, of the type **int** and value **43** (also, the **id** will be different), and the name **age** is set to point to it. So, in fact, we did not change that **42** to **43** - we actually just pointed **age** to a different location, which is the new **int** object whose value is **43**. let's see the same code also printing the IDs:

      - 

```
>>> age = 42
>>> id(age)
4377553168
>>> age = 43
>>> id(age)
4377553200
```

- Now, let's see the same example using a mutable object. For this example, let's just use a **Person** object, that has a property **age** (don't worry about the class declaration for now - it is there only for completeness):

  ◇

◇ 

```
>>> class Person:
...     def __init__(self, age):
...         self.age = age
...
>>> fab = Person(age=42)
>>> fab.age
42
>>> id(fab)
4380878496
>>> id(fab.age)
4377553168
>>> fab.age = 25  # I wish!
>>> id(fab)  # will be the same
4380878496
>>> id(fab.age)  # will be different
4377552624
```

◇

```
class Person:
    def __init__(self, age):
        self.age = age

fab = Person(age=42)

print('fab.age', '\n', fab.age)
print('id(fab)', '\n', id(fab))
print('id(fab.age)', '\n', id(fab.age))

fab.age = 25
print('id(fab)', '\n', id(fab))
print('id(fab.age)', '\n', id(fab.age))
```

▪ In this case we set up an object **fab** whose **type** is **Person** (a custom class). On creation, the object is given the age of 42. We then print it, along with the object **ID**, and the **ID of age** as well. Notice that, even after we change **age** to be **25**, the **ID** of **fab** stays the same (while the **ID** of **age** has changed, of course). **Custom objects in Python are mutable** (unless you code them not to be). Keep this concept in mind, as it's very important. We'll remind you about it throughout the rest of this chapter.

2.3 Numbers

- **Integers:**
  - ◇ **Python integers have an unlimited range, subject only to available virtual memory**. This means that it doesn't really matter how big a number you want to store is, as long as it can fit in your computer's memory, Python will take care of it.

  - ◇ Integer numbers can be positive, negative, or zero. They support all the basic mathematical operations, as shown in the following example:

```
a = 14
b = 3

a + b # addition
# result: 17

a - b # subtraction
# result: 11

a * b # multiplication
# result: 42

a / b # true divicion
# result: 4.666666666666667

a // b # integer division
# result: 4

a % b # modulo operation (ramainder of division)
# result: 2

a ** b # power operation
# result: 2744
```

  - ◇ Let's see how division behaves differently when we introduce negative numbers:

```
7 / 4 # true division
# result: 1.75

7 // 4 # integer division, truncation returns 1
# result: 1

-7 / 4 # true division again, result is opposite of previous
# result: -1.75

-7 // 4 #integer division, result not the ooposite of previous
# result: -2
```

- This is an interesting example. If you were expecting a -1 on the last line, don't feel bad, it's just the way Python works. **Integer division in Python is always rounded towards minus infinity**. If, instead of flooring, you want to truncate a number to an integer, you can use the built-in **int()** function, as shown in the following example:

→

```
int(1.75)
# result: 1

int(-1.75)
# result: -1
```

⇒ **Notice that the truncation is done toward 0**.

• Note: the **int()** function can also return integer numbers from string representation in a given base:

◇

```
int('10110', base=2)
# result: 22
```

◇ The **pow()** function allows a third argument to perform modular **exponentiation**. The form with three arguments now accepts a negative exponent in the case where the base is relatively prime to the modulus.

▪ The result is the **modular multiplicative inverse** of the base (or a suitable power of that. when the exponent is negative, but not -1), modulo the third argument. Here's an example:

```
pow(123, 4)
# result: 228886641

pow(123, 4, 100)
# result: 41
# basically: 228886641 % 100 == 41

pow(37, -1, 43) # modular inverse of 37 mod 43
# result: 7

7 ** 37 % 43 # proof the above is correct
# result: 7
```

-

◇ One nice feature introduced in python 3.6 is the ability to add underscores within number literals (between digits or base specifiers, but not leading or trailing). The purpose is to help make some numbers more readable, such as **1_000_000_00**:

```
n = 1_024
n
# result:1024

hex_n = 0x4_0_0 # 0x400 == 1024
hex_n
# result: 1024
```

▪

• **Booleans:**

◇ Booleans are a subclass of integers, so **True** and **False** behave respectively like **1** and **0**.

▪ **True** → **1**

▪ **False** → **0**

◇ Let's look at some examples:

▪

```
bool(-42)
# result: True  # and so does every non-zero number

not True
# result: False

not False
# result: True

True and True
# result: True

False or True
# result: True
```

- You can see that **True** and **False** are **subclasses of integers** when you try to add them. Python upcasts them to integers and performs the addition:

→

```
1 + True
# result: 2

False + 42
# result: 42

7 - True
# result: 6
```

• **Real numbers:**

◇ Several programming languages give coders two different formats:

- **single** → **takes up 32 bits of memory**

→ and

- **double precision** → **takes up 64 bits of memory** (the only one supported by Python)

▪ The former takes up **32 bits** of memory, the latter **64**. Python supports only the double format.

◇ The **sys.float_info** sequence holds information about how floating point numbers will behave on your system. This is an example of what you might see:

▪

```
import sys
sys.float_info
# result: sys.float_info(max=1.7976931348623157e+308,
#                        max_exp=1024, max_10_exp=308,
#                        min=2.2250738585072014e-308,
#                        min_exp=-1021, min_10_exp=-307,
#                        dig=15, mant_dig=53,
#                        epsilon=2.220446049250313e-16,
#                              radix=2, rounds=1)
```

- Let's make a few considerations here:

→ We have 64 bits to represent floating point number. This means we can represent at most 2^{64} (that is **12,446,744,073,709,551,616**) distinct numbers. Take a look at the **max** and **epsilon** values for the float numbers, and you will realize that it's impossible to represent them all. There is just not enough space, so they are approximated to the closest representable number. You probably think that only extremely big or extremely small numbers suffer from this issue. Well, think again and try the following in your console:

→

```
0.3 - 0.1 * 3 # this should be 0!!!
# result: -5.551115123125783e-17
```

⇒ in the authors' system this yielded:

•

```
0.09
```

◇ What does this tell you? It tells you that double precision numbers suffer from approximation issues even when it comes to simple numbers like **0.1** or **0.3**. **Why is this important? It cam be a big problem if you are handling prices, or financial calculations, or any kind of data that need not to be approximated**. Don't worry, Python gives you the **Decimal** type, which doesn't suffer from these issues. we'll see them in a moment.

• **Complex numbers:**

◇ Python gives you **complex numbers** support out of the box. Comple numbers are numbers that can be expressed in the form **a + ib**, where **a** and **b** are real numbers, and **i** (or **j** if you're an engineer) is the imaginary unit; that is the square root of **-1**. **a** and **b** are called, respectively, the **real** and **imaginary** part of the number.

◇ It is perhaps unlikely that you will use them, unless you're coding something scientific. Nevertheless, let's see a small example:

▪

```
c = 3.14 + 2.73j
c = complex(3.14, 2.73) # same as above
c.real # real part
# result: 3.14

c.imag # imaginary part
# result: 2.73

c.conjugate() # conjugate of A + Bj is A - Bj
# result: (3.14 - 2.73j)

c * 2 # multiplication is allowed
# result: (6.28 + 5.46j)

c ** 2 # power operation as well
# result: (2.4067000000000007+17.1444j)
```

```
d = 1 + 1j # addition and subtraction as well
c - d
(2.14 + 1.73j)
```

- **Fractions and decimals**:
  ◇ Let's finish the tour of the number department with a look at fractions and decimals. Fractions hold a rational numerator and denominator in their lowest forms. Let's see an example:
  ▪

```
from fraction import Fraction
Fraction(10, 6)
# result: Fractiion(5, 3) # notice it's been simplified

Fraction(1, 3) + Fraction(2, 3) # 1/3 + 2/3 == 3/3 == 1/1
# result: Fraction(1, 1)

f = Fraction(10, 6)
f.numerator
# result: 5
f.denominator
# result: 3
f.as_integer_ratio()
# result: (5, 3)
```

◇ The **as_integer_ratio()** method has also been added to integers and Booleans. This is helpful, as it allows you to use it without needing to worry about what type of number is being worked with.

◇ Although **Fraction** objects can be very useful at times, it's not that common to spot them in commercial software. Instead, it is much more common to see decimal numbers being used in all those contexts where precision is everything:

▪ For example in scientific and financial calculations.

- **Note:** It's important to remember that arbitrary precision decimal numbers come at a price in terms of performance, of course. The amount of data to be stored for each number is greater than it is for **Fractions** or **floats**. The way they are handled also requires the Python interpreter to work harder behind the scenes. Another interesting thing to note is that you can get and set the precision by accesing **decimal.getcontext().prec** .

◇ Let's see a quick example with decimal numbers:
▪

```
from decimal import Decimal as D # rename for brevity
D(3.14) # pi, from float, so approximation issues
# result:
Decimal('3.140000000000000124344978758017532527446746826171875')

D('3.14') # pi, from a string, so no approximation issues
Decimal('3.14')
```

```
D(0.1) * D(3) - D(0.3) # from float, we still have the issue
# result: Decimal('2.775557561565156540423631668E-17')

D('0.1') * D(3) - D('0.3') # from string, all perfect
# result: Decimal('0.0')

D('1.4').as_integer_ratio() # 7/5 = 1.4
# result: (7, 5)
```

- Notice that when we construct a Decimal number from a float, it takes on all the approximation issues a float may come with. On the other hand, when we create a Decimal from an integer or a string representation of a number, then the Decimal will have no approximation issues, and therefore no quirky behavior.

- When it comes to currency or situations in which precision is of utmost importance, use decimals.

2.4 Inmutable Sequences

- Let's start with immutable sequences:
  - **strings**
  - **tuples**
  - **bytes**

- **Strings and bytes:**
  - Textual data in Python is handled with **str** objects, more commonly known as **strings**. **They are immutable sequences** of **Unicode code points**. Unicode code points can represent a character, but can also have other meanings such as when formatting, for example. Python, unlike other languages, doesn't have a **char** type, so a single character is rendered simply by a string of length 1.

  - Unicode is an excellent way to handle data, and should be used for the internals of any application. When it comes to storing textual data though, or sending it on the network, you will likely want to encode it, using an appropriate encoding for the medium you are using. the result of an encoding produces a byte object, whose syntax and behavior is similar to that of strings. **String literals are written** in Python using **single**, **double**, or **triple quotes** (both single or double). If built with triple quotes, a string can span multiple lines, let's take a look at an example:

```python
# 4 ways to make a string
str1 = 'String with single quotes.'
str2 = "String with double quotes."
str3 = '''String with multiple lines,
so it can span multiple lines.'''
str4 = """This too
is a multiline one
built with triple double-quotes."""

str4 # A
# result: 'This too\nis a multiline one\nbuilt with triple double-quotes.'

print(str4) # B
# result: This too is a multiline one
# built with triple double-quotes.
```

- In **#A** and **#B**, we print **str4**, first implicitly, and then explicitly, using the **print()** function. A good exercise would be to find out why they are different (look up the **str()** and **repr()** functions.)

  - Strings, like any sequence, have a length. You can get this by calling the **len()** function:

```python
len(str1)
# result: 26
```

  - **Python 3.9** has introduced two new methods that deal with the prefixes and suffixes of strings. Here's an example that explains the way they work:

```
s = 'Hello There'
s.removeprefix('Hell')
# result: 'o There'

s.removesuffix('here')
# result: 'Hello T'

s.removepreffix('Ooops')
# result: 'Hello There'
```

- **The nice thing about them is shown by the last instruction:** when we attempt to remove a prefix or suffix which is not there, the method simply returns a copy of the original string. This means that these methods, behind the scenes, are checking if the prefix or suffix matches the argument of the call, and when that's the case, they remove it.

- **Encoding and decoding strings:**

◇ Using the **encode** / **decode** methods, **we can encode Unicode strings and decode bytes objects**. **UTF-8** is a variable length **character encoding**, capable of encoding all possible Unicode code points. It is the most widely used encoding for the web. Notice also that by adding the literal **b** in front of a string declaration, we're creating a bytes object:

▪

```
s = "This is üŋíc0de" # unicode string: code points
type(s)
# result: <class 'str'>

encoded_s = s.encode('utf-8') # utf-8 encoded version of s
encoded_S
# result: b'This is \xc3\xbc\xc5\x8b\xc3\xadc0de' # result: bytes
object

type(encoded_s) # another to verify it
# result: <class 'bytes'>

encoded_s.decode('utf-8') # let's revert to the original
# result: 'This is üŋíc0de'

bytes_obj = b"A bytes object" # a bytes object
type(bytes_obj)
# result: <class 'bytes'>
```

- **Indexing and slicing strings:**

◇ When manipulating sequences, it's very common to access them at one precise position (**indexi-ng**), or to get a sub-sequence out of them (**slicing**). **When dealing with immutable sequences, both operations are read-only**.

◇ While indexing comes in one form (zero based access to any position within the sequence) slicing comes in different forms. When you get a slice of a sequence, you can specify the **start** and **stop** positions, along with the **step**. They are separated with a colon (**:**) like this:

▪ **my_sequence[start:stop:step]**

▪ All the arguments are optional; **start** is inclusive, and **stop** is exclusive. Let's take a look at an example:

-

```
s = "The trouble is you think you have time."
s[0] # Indexing at position 0, which is the first char
# result: 'T'

s[5] # indexing at position 5, which is the sixth char
# result: 'r'

s[:4] # slicing, we specify only the stop position
# result: 'The '

s[4:] # slicing, we specify only the start position
# result: 'trouble is you think you have time.'

s[2:14] # Slicing, both start and stop positions
# result: 'e trouble is'

s[2:14:3] # Slicing, start, stop and step (every 3 chars)
# result: 'erb '

s[:] # quick way of making a copy
# result: 'The trouble is you think you have time.'
```

→ The last line is quite interesting. If you don't specify any of the parameters, Python will fill in the defaults for you. In this case, **start** will be the start of the string, **stop** will be the end of the string, and **step** will be the default: **1**. This is an easy and quick way of obtaining a copy of the string **s** (the same value but a different object).

→ To get the reversed copy of a string using slicing:

⇒

```
s[::-1]
```

- **String formatting:**

◇ One of the features strings have **is the ability to be used as a template**. There are several different ways of formatting a string, and for the full list of possibilities, we encourage you to look up the documentation. Here are some common examples:

▪

```
greet_old = 'Hello %s'
greet_old % 'Fabrizio!'
# result: 'Hello Fabrizio!'

greet_positional = 'Hello {}!'
greet_positional.format('Fabrizio!')
# result: 'Hello Fabrizio!'

greet_positional = 'Hello {} {}!'
greet_positional.format('Fabrizio', 'Romano')
```

```
# result: 'Hello Fabrizio Romano!'

greet_positional_idx = 'This is {0}! {1} loves {0}'
greeet_positional_idx.format('Python!', 'Heinrich')
# result: 'This is Python! Heinrich loves Python!'

greet_positional_idx.format('Coffee!', 'Fab')
# result: 'This is Coffee! Fab loves Coffee!'

keyword = 'Hello, my name is {name} {last_name}'
keyword.format(name='Fabrizio', last_name='Romano')
# result: 'Hello, my name is Fabrizio Romano'
```

- In the previous example, you can see four different ways of formatting strings.

→ The first one, which relies on the **%** operator, is deprecated and shouldn't be used anymore.

→ The current, modern way to format a string is by using the **format()** string method. You can see, from the different examples, that a pair, of curly braces, acts as a placeholder within the string.

⇒ When we call **format()**, we feed it data that replaces the placeholders. We can specify indexes (and much more) within the curly braces, and even names, which implies we'll have to **format ()** using keyword arguments instead of positional ones.

- Notice how **greet_positional_idx** is rendered differently by feeding different data to the call to **format**.

◇ One last feature we'll take a look at was added to Python in version 3.6, and it's called **formatted string literals**. This feature is quite cool (and it is faster than using the **format()** method): strings are prefixed with **f**, and contain replacement fields surrounded by curly braces.

▪ Replacement fields are expressions evaluated at runtime, and then formatted using the format protocol:

-

```
name = 'Fab'
age = 42
f"Hello! My name is {name} and I'm {age}"
# result: "Hello! My name is Fab and I'm 42"

from math import pi
f"No arguing with {pi}, it's irrational..."
# result: "No arguing with 3.141592653589793, it's irrational..."
```

▪ An interesting addition to f-strings, which was introduced in Python 3.8, is the ability to add an equals sign specifier within the f-string clause; this causes the expression to expand to the text of the expression, an equals sign, then the representation of the evaluated expression. **This is great for self-documenting and debugging purposes**. Here's an example that shows the difference in behavior:

-

```
user = 'heinrich'
```

```
password = 'super-secret'
f"Log in with: {user} and {password}"
# result: 'Log in with heinrich and super-secret'

f"Log in with: {user=} and {password=}"
# result: "Log in with: user='heinrich' and password='super-secret'"
```

- **Tuples**:

  ◇ The last immutable sequence type we are going to look at here is the tuple. **A tuple is sequence of arbitrary Python objects**. In a tuple declaration, items are separated by commas. Tuples are used everywhere in Python. They allow for patterns that are quite hard to reproduce in other languages. Sometimes tuples **are used** implicitly; for example, to set up multiple variables on one line, or **to allow a function to return multiple objects** (in several languages, it is common for a function to return only one object), and in the Python console, tuples can be used implicitly to print multiple elements with one single instruction. We'll see examples for all these cases:

▪

```
t = () # empty tuple
type(t)
# result: <class 'tuple'>

one_element_tuple = (42, ) # you need the comma!
three_elements_tuple = (1, 3, 5) # braces are optional here

a, ,b, c = 1, 2, 3 # tuple for multiple assignment
a, b, c  # implicit tuple to print with one instruction
# result: (1, 2, 3)

3 in three_elements_tuple # membership test
# result: True
```

- **Notice that the membership operator can also be used with:**

  → **lists**

  → **strings**

  → **dictionaries**

  → **and in general, with collection and sequence objects**.

→ Note: Notice that to create a tuple with one item, we need to put a comma after the item. The reason is that without the comma that item is wrapped in braces on its own, in what can be considered a redundant mathematical expression. Notice also that on assignment, braces are optional, so:

⇒ **my_tuple = 1, 2, 3**

- **is the same as:**

⇒ **my_tuple = (1, 2, 3)**.

◇ One thing that tuple assignment allows us to do is one-line swaps, with no need for a third temporary variable. Let's first see the traditional way of doing it:

▪

```
a, b = 1, 2
c = a # we need three lines and a temporary var c
a = b
b = c
a, b # result: a and b have been swapped
(2, 1)
```

◇ Now let's take a look at the modern way of doing it:

▪
```
a, b = 0, 1
a, b = b, a # this is the Pythonic way to do it
a, b
# result: (1, 0)
```

◇ **Because they are immutable, tuples can be used as keys for dictionaries** (we'll see this shortly). **To us Tuples are Python's built in data that most closely represent a mathematical vector**. This doesn't mean that this was the reason for which they were created, though. **Tuples usually contain a heterogenous sequence of elements** while, on the other hand, **lists are, most of the time, homogenous**. **Moreover, tuples are normally accessed via unpacking or indexing**, **while lists are usually iterated over**.

2.5 Mutable Sequences

• **Mutable sequences differ from their immutable counterparts in that they can be changed after creation**. There are two mutable sequence types in Python:

▪ **lists**

▪ **byte arrays**.

• **Lists**:

◇ **Python lists are very similar to tuples, but they don't have the restrictions of immutability.** Lists **are commonly used for storing collections of homogeneous objects**, **but there is nothing preventing you from storing heterogeneous collections as well**. Lists can be created in many different ways. Let's see an example:

▪

```
[] # empty list

list() # same as []
# result: []

[1, 2, 3] # as with tuples, items are comma separated
# result: [1, 2, 3]

[x + 5 for x in [2, 3, 4]] # Python is magic
# result: [7, 8, 9]

list((1, 3, 5, 7, 9)) # list from a tuple
# result: [1, 3, 5, 7, 9]

list('hello') # list from a string
# result: ['h', 'e', 'l', 'l', 'o']
```

- In the previous example, we showed you how to create a list using various techniques.

- We would like you to take a good look at the line with the comment **Python is magic** , which we don't expect you to fully understand at this point. That is called a **list comprehension**: a very powerful functional feature of Python.

◇ Creating lists is good, but the real fun begins when we use them, so let's see the main methods they gift us with:

▪

```
a = [1, 2, 1, 3]
a.append(13) # we can append anything at the end
a
# result: [1, 2, 1, 3, 13]

a.count(1) # how many 1's are there in the list?
# result: 2

a.extend([5, 7]) # extend the list by another (or sequence)
a
# result: [1, 2, 1, 3, 13, 5, 7]
```

```
a.index(13) # position of '13' in the list (0-based indexing)
# result: 4

a.insert(0, 17) # insert '17' at position 0
a
# result: [17, 1, 2, 1, 3, 13, 5, 7]

a.pop() # pop (remove and return) last element
# result: 7

a.pop(3) # pop element at position 3
# result: 1
a
# result: [17, 1, 2, 3, 13, 5]

a.remove(17) # remove '17' from the list
a
# result: [1, 2, 3, 13, 5]

a.reverse() # reverse the order of the elements in the list
a
# result: [5, 13, 3, 2, 1]

a.sort() # sort the list
# result: [1, 2, 3, 5, 13]

a.clear() # remove all elements from the list
a
# result: []
```

- The preceding code gives you a roundup of a list's main methods.
- We will see how powerful they are, using the method **extend()** as an example, you can extend lists using any sequence type:

-

```
a = list('hello') # makes a list from a string
a
# result: ['h', 'e', 'l', 'l', 'o']

a.append(100) # append 100, heterogenous type
a
# result: ['h', 'e', 'l', 'l', 'o', 100]

a.extend((1, 2, 3)) # extend using tuple
a
# result: ['h', 'e', 'l', 'l', 'o', 100, 1, 2, 3]

a.extend('...') # extend using string
a
# result: ['h', 'e', 'l', 'l', 'o', 100, 1, 2, 3, '.', '.', '.']
```

◇ Now let's see the most common operations you can do with lists:

-
```
a = [1, 3, 5, 7]
```

```
min(a) # minimum value in the list
# result: 1

max(a) # maximum value in the list
# result: 7

sum(a) # sum of all values in the list
# result: 16

from math import prod
prod(a) # product of all values in the list
# result: 105

len(a)
# result: 4

b = [6, 7, 8]
a + b # '+' with lsit means concatenation
# result: [1, 3, 5, 7, 6, 7, 8]

a * 2 # '*' has also a special meaning
# result: [1, 3, 5, 7, 1, 3, 5, 7]
```

- Notice how easily we can perform the **sum** and the **product** all values in a list. The function **prod()**, from the **math** module, is just one of the many new additions introduced in **Python 3.8**, Even if you don't plan to use it that often, it's always a good idea to check out the **math** module and be familiar with its functions, as they can be quite helpful.

- The last two lines in the preceding code are also quite interesting, as they introduce us to a concept called **operator overloading**. In short, this means that operators, such as **+**, **-**, *****, **%**, and so on, may represent different operations according to the context they are used in. It doesn't make any sense to sum two lists, right? Therefore the **+** sign is used to concatenate them. Hence, the ***** sign is used to concatenate the list to itself according to the right operand.

◇ Now, let's take a step further and see something a little more interesting. We want to show you how powerful the **sorted** method can be and how easy it is in Python to achieve results that require a great deal of effort in other languages:

▪

```
from operator import itemgetter
a = [(5, 3), (1, 3), (1, 2), (2, -1), (4, 9)]
sorted(a)
# result: [(1, 2), (1, 3), (2, -1), (4, 9), (5, 3)]

sorted(a, key=itemgetter(0))
# result: [(1, 3), (1, 2), (2, -1), (4, 9), (5, 3)]

sorted(a, key=itemgetter(0, 1))
# result: [(1, 2), (1, 3), (2, -1), (4, 9), (5, 3)]

sorted(a, key=itemgetter(1))
# result: [(2, -1), (1, 2), (5, 3), (1, 3), (4, 9)]

sorted(a, key=itemgetter(1), reverse=True)
```

```
# result: [(4, 9), (5, 3), (1, 3), (1, 2), (2, -1)]
```

- In the preceding code, **a** is a list of tuples. This means each element in **a** is a tuple (a 2-tuple in this case).
- When we call **sorted(my_list)**, we get a sorted version **my_list**.
  → **In this case the sorting on a 2-tuple works by sorting them on the first item in the tuple, and on the second when the first one is the same.** You can see this behavior in the result of **sorted(a)**, which yields **[(1, 2), (1, 3), (2, -1), (4, 9), (5, 3)]**.
- Python also gives us the ability to control which element(s) of the tuple the sorting must be run against.
  → Notice that when we instruct the **sorted** function, to work on the first element of each tuple (with **key=itemgetter(0)**), the result is different: **[(1, 3), (1, 2), (2, -1), (4, 9), (5, 3)]**.
    ⇒ The sorting is done only on the first element of each tuple (which is the one at position 0).
  → If we want to replicate the default behavior of a simple **sorted(a)**, we need to use the **key =itemgetter(0, 1)**, which tells Python to sort first on the elements at position **0** within the tuples, and then on those at position **1**. Compare the results and you will they match.
- For completeness. an example of sorting only on the elements at position 1, and then again, with the same sorting but in reverse order.

▪ The Python sorting algorithm is very powerful, and it was written by Tim Peters. It is aptly named, **Timsort**, and it is a blend between **merge** and **insertion sort** and has better time performances than most other algorithms used for mainstream programming languages. Timsort is a stable **sorting algorithm**, which means that when multiple records score the same in the comparison, their original order is preserved. We've seen this in the result of **sorted(a, key=itemgetter(0))**, which yielded **[(1, 3), (1, 2), (2, -1), (4, 9), (5, 3)]**, in which the order of those tuple had been preserved because they had the same value at position **0**.

• **Bytearrays:**

◇ To conclude our overview of the mutable sequence types, let's spend a moment of the **bytearray** type. Basically, they represent the mutable version of bytes objects. They expose most of the usual methods of mutable sequences as well as most of the methods of the bytes array type. Items in a bytearray are integers in the range **[0, 256)**.

▪ **Note**: When it comes to intervals, we are going to use the standard notation for open/closed ranges. A **square bracket on one end means that the value is included**, while a **round bracket means that it is excluded**. The granularity is usually inferred by the type of the edge elements so, for example, the interval **[3, 7]** means all integers between 3 and 7, inclusive. On the other hand, (3, 7) means all integers between 3 and 7, exclusive (4, 5 and 6).

◇ **Items in a bytearray type are integers between 0 and 256; 0 is included, 256 is not**; One reason that intervals are often expressed like this is to ease coding.

◇ Let's see an example with the **bytearray** type:

▪

```
bytearray() #empty bytearray object
# result: bytearray(b'')

bytearray(10) # zero-filled instancce with given length
# result: bytearray(b'\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00')

bytearray(range(5)) # bytearray from iterable of integers
# result: bytearray(b'\x00\x01\x02\x03\x04')

name = bytearray(b'Lina') # A - bytearray from bytes
name.replace(b'L', b'l')
# result: bytearray(b'lina')

name.endswith(b'na')
# result: True

name.upper()
# result: bytearray(b'LINA')

name.count(b'L')
# result: 1
```

- As you can see, there are a few ways to create a **bytearray** object.

- **They can be useful in many situations; for example, when receiving data through a socket, they eliminate the need to concatenate data while polling, hence they can prove to be very handy**.

- On line **#A**, we created a **bytearray** named as **name** from the bytes literal **b'Lina' to show you how the bytearray object exposes methods from both sequences and strings**, which is extremely handy. If you think about it, they can be considered as mutable strings.

2.6 Set Types

- Python also provides two set types:
  - ◇ **set**
    - ▪ and
  - ◇ **frozenset**.

◇ **The set type is mutable, while frozenset is immutable. They are unordered collections of immutable objects**.

◇ **Hashability** is a characteristic that allows an object to be used as a set member as well as a key for a dictionary, as we'll see very soon.

▪ **Note:** from the official Python documentation (https://docs.python.org/3.9/glossary.html)

- "An object is hashable if it has a hash value which never changes during its lifetime and can be compared to other objects. **Hashability makes an object usable as a dictionary key and a set member**, because these data structures use the hash value internally. **Most of Python's immutable built-in objects are hashable; mutable containers (such as lists or dictionaries) are not**; **immutable containers (such as tuples and frozenset are only hashable if their elements are hashable**. **Objects which are instances of user-defined classes are hashable by deafault**. They all compare unequal (except with themselves), and their hash value is derived from their **id()** "

◇ Objects that compare equally must have the same value. Sets are very commonly used to test for membership; let's introduce the **in** operator in the following example:

▪

```
small_primes = set() # empty set
small_primes.add(2) # adding one element at a time
small_primes.add(3)
small_primes.add(5)
small_primes
# result: {2, 3, 5}

small_primes.add(1) # look what I've done, 1 is not a prime!
small_primes
#result: {1, 2, 3, 5}

small_primes.remove(1) # so let's remove it
3 in small_primes # membership test
#result: True

4 in small_prime
#result: False

4 not in small_primes # negated membership test
#result: True

small_primes.add(3) # trying to add 3 again
small_primes
#result: {2, 3, 5} # no change, duplication is not allowed
```

```
bigger_primes = set([5, 7, 11, 13]) # faster creation
small_primes | bigger_primes # union operator '|'
#result: {2, 3, 5, 7, 11, 13}

small_primes & bigger_primes # intersection operator '&'
#result: {5}

small_primes - bigger_primes # difference operator '-'
#result: {2, 3}
```

- In the preceding code you can see two different ways to create a set:

- One creates an empty set and then adds elements one at a time.

- The other creates the set **using a list of numbers** as an argument to the constructor, which does all the work for us. Of course, you can create a set from a list or tuple (or any iterable) and then you can add and remove members from the set as you please.

→ **Note**: We'll look at iterable objects and iteration in the next chapter. For now, just know that iterable objects are objects you can iterate on in a direction.

◇ Another way of creating a set is by simply using the curly braces notation, like this:

▪
```
small_primes = {2, 3, 5, 5, 3}
small_primes
# result: {{2, 3, 5}
```

- notice we added some duplication to emphasize that the resulting set won't have any. Let's see an example using the immutable counterpart of the set type, **frozenset** :

→

```
small_primes = frozenset([2, 3, 5, 7])
bigger_primes = frozenset([5, 7, 11])
small_primes.add(11) # we cannot add to a frozenset
# result: Traceback (most recent call last):
#  File "<stdin>", line 1, in <module>
# AttributeError: 'frozenset' object has no attribute 'add'

small_primes.remove(2) # nor can we remove
# result: Traceback (most recent call last):
#  File "<stdin>", line 1, in <module>
# AttributeError: 'frozenset' object has no attribute 'remove'

small_primes & bigger_primes # intersect, union, etc. is allowed
# result: frozenset({5, 7})
```

⇒ As you can see, **frozenset** objects are quite limited with respect to their mutable counterpart.

• They still prove very effective for **membership test**, **union**, **intersection**, and **difference operations**, and **for performance reasons**.

2.7 Mapping types: Dictionaries

• Of all the built-in data types, the dictionary is easily the most interesting. It's the only standard mapping type, and it is the backbone of every Python object.

• **A dictionary maps keys to values**. **Keys need to be hashable objects, while values can be of any arbitrary type**.

◇ **Dictionaries are also mutable objects**.

◇ There are quite a few different ways to create a dictionary, so let us give you a simple example of how to create a dictionary equal to **{'A' : 1, Z: -1}** in five different ways:

▪
```
a = dict(A=1, Z=-1)
b = {'A': 1, 'Z': -1}
c = dict(zip(['A', 'Z'], [1, -1]))
d = dict([('A', 1), ('Z', -1)])
e = dict({'Z': -1, 'A': 1})

a == b == c == d == e # are they all the same?
# result: True # They are indeed
```

- Have you noticed those double equals? Assignment is done with one equal, while to check whether an object is the same as another one (or five in one go, in this case), we use the double equals.

- There is also another way to compare objects, which involves the **is** operator, and checks whether the two objects are the same (**that is, that they have the same ID, not just the same value**), but unless you have a good reason to use it, you should use the double equals instead. In the preceding code, we also used one nice function: **zip()**. It is named after the real-life zip, which glues together two parts, taking one element from each part at a time. Let's see an example:

→

```
list(zip(['h', 'e', 'l', 'l', 'o'], [1, 2, 3, 4, 5]))
# result: [('h', 1), ('e', 2), ('l', 3), ('l', 4), ('o', 5)]

list(zip('hello', range(1, 6))) # equivalent, more Pythonic
# result: [('h', 1), ('e', 2), ('l', 3), ('l', 4), ('o', 5)]
```

⇒ In the preceding example, we have created the same list in two different ways, one more explicit, and the other a little bit more Pythonic.

• Forget for a moment that we had to wrap the **list()** constructor around the **zip()** call (the reason is **zip()** returns an iterator, not a **list**, so if we want to see the result, we need to exhaust that iterator into something (a list in this case).), and concentrate on the result. See how **zip()** has coupled the first elements of its two arguments together, then the second ones, then the third ones, and so on?

◇ Take a look at the zip of your suitcase, or a purse, or the cover of a pillow, and you will see it works exactly like the one in Python. But let's go back to dictionaries and see how many wonderful methods they expose for allowing us to manipulate the as we want. Let's start with the basic operations:

▪

```
d = {}
d['a'] = 1 # let's set a couple of (key, value) pairs
d['b'] = 2
len(d) # how many pairs
# result: 2

d['a'] # what is the value of 'a'?
# result: 1

d # how does 'd' look now
# result:{'a': 1, 'b': 2}

del d['a'] # let's remove 'a'
d
# result: {'b': 2}

d['c'] = 3 #let's add 'c': 3
'c' in d # membership is checked against the keys
# result: True

3 in d # not the values
# result: False

'e' in d
False

d.clear() # let's clean everything from this dictionary
d
# result: {}
```

- Notice how accessing keys of a dictionary, regardless of the type of operation we're performing, is done using square brackets. Do you remember, strings, lists, and tuples? We were accessing elements at some position through square brackets as well, which is yet another example of Python's consistency.

◇ Let's now take a look at three special objects called dictionary views : **keys**, **values**, and **items**. These objects provide a dynamic view of the dictionary entries and they change when the dictionary changes. **keys()** returns all the keys in the dictionary, **values() returns all the values in the dictionary**, and **items() returns all the** (**key**, **value**) **pairs in the dictionary**. Let's put all this down into code:

▪

```
d = dict(zip('hello', range(5)))
d
# result: {'h': 0, 'e': 1, 'l': 3, 'o': 4}

d.keys()
# result: dict_keys(['h', 'e', 'l', 'o'])

d.values()
# result: dict_values([0, 1, 3, 4])

d.items()
# result: dict_items([('h', 0), ('e', 1), ('l', 3), ('o', 4)])
```

```
3 in d.values()
# result: True

('o', 4) in d.items()
# result: True
```

- There are a few things to note here.

→ First, notice how we are creating a dictionary by iterating over the zipped version of the string '**hello**' and the list **[0, 1, 2, 3, 4]**.

→ The string '**hello**' has two '**l**' characters inside, and they are paired up with the values **2** and **3** by the **zip()** function. Notice how in the dictionary, the second occurrence of the '**l**' key (**the one with value 3**), overwrites the first one (**the one with the value 2**).

→ Another thing to notice is that when asking for any view, the original order in which items were added is now preserved, while before version **3.6** there was no guarantee of that.

◇ As of Python 3.6, the **dict** type has been re-implemented to use a more compact representation. This resulted in dictionaries using 20% to 25% less memory when compared to Python 3.5. Moreover, since Python 3.6, as a side effect, dictionaries preserve the order in which keys were inserted. This feature has received such a welcome from the community that in 3.7 it has become an official feature of the language rather than an implementation side effect. Since Python 3.8, dictionaries are also reversible.

◇ We'll see how these views are fundamental tools when we talk about iterating over collections. Let's take a look now at some other methods exposed by Python's dictionaries (there's plenty of them and they're very useful):

▪

```
d
# result: {'h': 0, 'e': 1, 'l': 3, 'o': 4}

d.popitem()
# result: ('o', 4)

d.pop('l') # remove item with key 'l'
# result: 3

d.pop('not-a-key') # remove a key not in dictionary
# result: Traceback (most recent call last):
#  File "<stdin>", line 1, in <module>
# KeyError: 'not-a-key'

d.pop('not-a-key', 'default-value') # with a default value?
# result: 'default-value'

d.update({'another': 'value'}) # we can update dict this way
d
# result: {'h': 0, 'e': 1, 'another': 'value'}

d.update(a=13) # or this way (like a function call)
d
```

```
# result: {'h': 0, 'e': 1, 'another': 'value', 'a': 13}

d.get('a') # same as d['a'] but if key is missing no KeyError
# result: 13

d.get('a', 177) # default value used if key is missing
# result: 13

d.get('b', 177) # like in this case
# result: 177

d.get('b') # key is not there, so None is returned
```

- All these methods are quite simple to understand, but it's worth talking about that **None**, for a moment.

- Every function in Python returns **None**, unless the **return** statement is explicitly used to return something else, but we´ll see this when we explore functions.

→ **None** is frequently used to represent the absence of a value, and it is quite commonly used as a default value for arguments in function declaration.

⇒ Some inexperienced coders sometimes write code that returns either **False** or **None**. both **False** and **None** evaluate to **False** in Boolean context, so it may seem that there is not much difference between them. But actually, we would argue the contrary, that there is an important difference: **False means that we have information**, and the information we have is **False**. **None** means **no information**; **no information** is very different from information that is **False**. In layman's terms, if you ask your mechanic Is my car ready?, there is a big difference between the answer No, it's not (**False**) and I have no idea (**None**).

◇ One last method we really like about dictionaries is **setdefault()**. It behaves like **get()**, but also sets the key with the given value if it is not there. Let's see an example:

▪

```
d = {}
d.setdefault('a', 1) # 'a' is missing, we get default value
# result: 1

d
# result: {'a': 1} # also the key/value pair ('a', 1) has now been
added

d.setdefault('a', 5) # let's try to override the value
# result: 1
d
# result: {'a': 1} # no override as expected
```

◇ This brings us to the end of this tour of dictionaries. Test your knowledge about them by trying to foresee what **d** looks like after this line:

▪

```
d = {}
d.setdefault('a', {}).setdefault('b', []).append.(1)
```

◇ Python 3.9 sports a brand-new union operator available for **dict** objects, which was introduced by PEP 584.

▪ When it comes to applying union to **dict** objects, we need to remember that union for them is not commutative. This becomes evident when the two **dict** objects we're merging have one or more keys in common. Check out this example:

-
```
d = {'a': 'A', 'b': 'B'}
e = {'b': '8', 'c': 'C'}
d | e
# result: {'a': 'A', 'b': 8, 'c': 'C'}

e | d
# result: {'b': 'B', 'c': 'C', 'a': 'A'}

{**d, **e}
# result: {'a': 'A', 'b': '8', 'c': 'C'}
```

→ Here, **dict** objects **d** and **e** have the key '**b**' in common.

→ For the **dict** object, **d**, the value associated with '**b**' is '**B**'; whereas, for **dict e**, it's the number **8**.

⇒ This means that when we merge them with **e** on the right hand side of the union operator, **|**, the value in **e** overrides the one in **d**.

⇒ The opposite happens, of course, when we swap the positions of those objects in relation to the unique operator.

→ In this example, you can also see how the **union** can be performed by using the ****** operator to produce a **dictionary unpacking**.

→ It's worth noting that union can also be performed as an augmented assignment operation (**d |= e**), which works in place. Please refer to **PEP 584** for more information about this feature.

2.8 Data Types

• Python provides a variety of specialized data types, such as **dates** and **times**, **container types**, and **enumerations**. There is a whole section in the Python standard library titled Data Types, which deserved to be explored; it is filled with interesting and useful tools for each and every programmer's needs.

  ▪ You can find it here → https://docs.python.org/3/library/datatypes.html

• In this section, we are briefly going to take a look at:

  ◇ **dates** and **times**

  ◇ **collections**

  ◇ **enumerations**.

• **Dates and times:**

The Python standard library provides several data types that can be used to deal with dates and times. this realm may seem innocuous at first glance, but it's actually quite tricky: time zones, daylight saving time... **There are a huge number of ways to format date and time information**; calendar quirks, parsing, and localizing; these are just a few of the many difficulties we face when we deal with dates and times, and
that's probably the reason why, in this particular context, it is very common for Python professional programmers to also rely on various third-party libraries that provide some much-needed extra power.

  ◇ **The standard library**:

  ▪ We will start with the **standard library**, and finish the session with a little overview of what's out there in terms of the third-party libraries you can use.

  ▪ From the standard library, the main modules that are used to handle dates and times are

  - **datetime**
  - **calendar**
  - **zoneinfo**
  - **time**.

  ▪ Let's start with the imports you'll need for this whole section:

  -

```
from datetime import date, datetime, timedelta, timezone
import time
import calendar as cal
from zoneinfo import ZoneInfo
```

  ▪ The first example deals with dates. Let's see how they look:

  -

```
today = date.today()
today
# result: datetime.date(2022, 12, 19)

today.ctime()
# result: 'Mon Dec 19 00:00:00 2022'
```

```
today.isoformat()
# result: '2022-12-19'

today.weekday()
# result: 0

cal.day_name[today.weekday()]
# result: 'Monday'

today.day, today.month, today.year
# result: (19, 12, 2022)

today.timetuple()
# result: time.struct_time(tm_year=2022, tm_mon=12, tm_mday=19,
tm_hour=0, tm_min=0, tm_sec=0, tm_wday=0, tm_yday=353, tm_isdst=-1)
```

→ We start by fetching the date for today. We can see that it's an instance of the **datetime.date** class. Then we get two different representations for it, following the **C** and **ISO 8601** format standards, respectively. After that, we ask what day of the week it is, and we get the number 0. Days are numbered 0 to 6 (representing Monday to Sunday), so we grab the value of the zero element in **cal.day_name** (notice in the code that we have substituted **calendar** with "**cal**" for brevity).

→ The last two instructions show how to get detailed information out of a date object. We can inspect its **day**, **month** and **year** attributes, or call the **timetuple()** method and get a whole wealth of information. Since we're dealing with a date object, notice that all the information about time has been set to 0.

- Let's now play with time:
  -

```
time.ctime()
# result: 'Mon Dec 19 15:24:49 2022'

time.daylight
# result: 0

time.gmtime()
# result: time.struct_time(tm_year=2022, tm_mon=12, tm_mday=19,
tm_hour=20, tm_min=27, tm_sec=6, tm_wday=0, tm_yday=353, tm_isdst=0)

time.gmtime(0)
# result: time.struct_time(tm_year=1970, tm_mon=1, tm_mday=1,
tm_hour=0, tm_min=0, tm_sec=0, tm_wday=3, tm_yday=1, tm_isdst=0)

time.localtime()
# result: time.struct_time(tm_year=2022, tm_mon=12, tm_mday=19,
tm_hour=15, tm_min=28, tm_sec=6, tm_wday=0, tm_yday=353, tm_isdst=0)

time.time()
# result: 1671481745.3147464
```

→ This example is quite similar to the one before, only here, we are dealing with time. We can see how to get a printed representation of time **according to C format standard**, and **then how to check if daylight saving time is in effect**. The function **gmtime converts a given number of**

seconds from the epoch to a struct_time object in UTC. If we don't feed it any number, it will use the current time.

→ We finish the example by getting the object for the current local time and the number of seconds from the epoch expressed as a float number:

⇒ **time.time()**

▪ Let's now see an example using **datetime** object, **which brings together dates and times**:

-

```
now = datetime.now()
utcnow = datetime.utcnow()
now
# result: datetime.datetime(2022, 12, 19, 15, 39, 47, 433418)
utcnow
# result: datetime.datetime(2022, 12, 19, 20, 40, 42, 504282)

now.date()
# result: datetime.date(2022, 12, 19)

now.day, now.month, now.year
# result: (19, 12, 2022)

now.date() == date.today()
# result: true

now.time()
#result: datetime.time(15, 40, 34, 360165)

now.hour, now.minute, now.second, now.microsecond
#result:(15, 40, 34, 360165)

now.ctime()
#result: 'Mon Dec 19 15:40:34 2022'

now.isoformat()
#result: '2022-12-19T15:40:34.360165'

now.timetuple()
#result: time.struct_time(tm_year=2022, tm_mon=12, tm_mday=19,
tm_hour=15, tm_min=40, tm_sec=34, tm_wday=0, tm_yday=353,
tm_isdst=-1)

now.tzinfo
utcnow.tzinfo
now.weekday()
#result: 0
```

→ The preceding example is rather self explanatory:

⇒ We start by setting up two instances that represent the current time. One is related to UTC (**utcnow**), and the other one is a local representation (**now**).

• You can get **date**, **time**, and specific attributes from a **datetime** object in a similar way as to what we have already seen. It is also worth noting how both **now** and **utcnow** present the value **None** for the **tzinfo** attribute. This happens because those objects are **naive**.

- **Note**: **Date** and **time objects can be categorized as aware if they include time zone information**, or **naive if they don't**.

◇ Let's now see how a duration is represented in this context:

▪

```
f_bday = datetime(1975, 12, 29, 12, 50, tzinfo=ZoneInfo('Europe/
Rome'))

h_bday = datetime(
1981, 10, 7, 15, 30, 50, tzinfo=timezone(timedelta(hours=2))
)

diff = h_bday - f_bday
type(diff)
# result: <class 'datetime.timedelta'>

diff.days
# result: 2109

diff.total_seconds()
# result: 182223650.0

today + timedelta(days=49)
# result: datetime.date(2021, 5, 16)

now + timedelta(weeks=7)
# result: datetime.datetime(2021, 5, 16, 25, 16, 258274)
```

- Two objects have been created that represent Fabrizio and Heinrich's birthdays. This time, in order to show you the alternative, we have created **aware** objects.

- There are several ways to include time zone information when creating a **datetime** object, and in this example, we are showing you two of them:
→ One uses the brand-new **ZoneInfo** object from the **zoneinfo** module, introduced in Python 3.9.
→ The second uses a simple **timedelta**, an object that represents a duration.

- We then create the **diff** object, which is assigned as the subtraction of them. The result of that operation is an instance of **timedelta**. You can see how we interrogate the **diff** object to tell us how many days Fabrizio and Heinrich's birthday are apart, and even the number of seconds that represent that whole duration. Notice that we need to use **total_seconds**, which expresses the whole duration in seconds. The **seconds** attribute represents the number of seconds assigned to that duration. So a **t-imedelta(days=1)** will have seconds equal to **0**, and **total_seconds** equal to **86,400** (which is the number of seconds in a day).

- Combining a **datetime** with a duration adds or subtracts that duration from the original date and time information. In the last few lines of the example, we can see how adding a duration to a date object produces a **date** as a result, whereas adding it to a **datetime**, as it is fair to expect.

◇ One of the more difficult undertakings to carry out using dates and times is **parsing**. Let's see a short example:

▪

```
datetime.formisoformat('1977-11-24T19:30:13+01:00')
# result: datetime.datetime(1977, 11, 24, 19, 30, 13,
tzinfo=datetime.timezone(datettime.timedelta(seconds=3600)))

datetime.fromtimestamp(time.time())
# result: datetime.datetime(2021, 3, 28, 15, 42, 2, 142696)
```

- We can easily create **datetime** objects from ISO-formatted strings, as well as from timestamps. **However, in general, parsing a date from unknown formats can prove to be a difficult task.**

2.8.1 Third-party libraries

- To finish off this subsection, we would like to mention a few third-party libraries that you will very likely come across the moment you will have to deal with dates and times in your code:
  - **dateutil**:
    - Powerful extension to **datetime**
      - https://dateutil.readthedocs.io/en/stable/
  - **Arrow**:
    - Better date and time for Python
      - https://arrow.readthedocs.io/en/latest/
  - **pytz**:
    - World time zone defintions for Python
      - https://pythonhosted.org/pytz/

- These three are some of the most common, and they are worth investigating.

- Le'ts take a look at one final example, this time using the **Arrow** third-party library:
  -

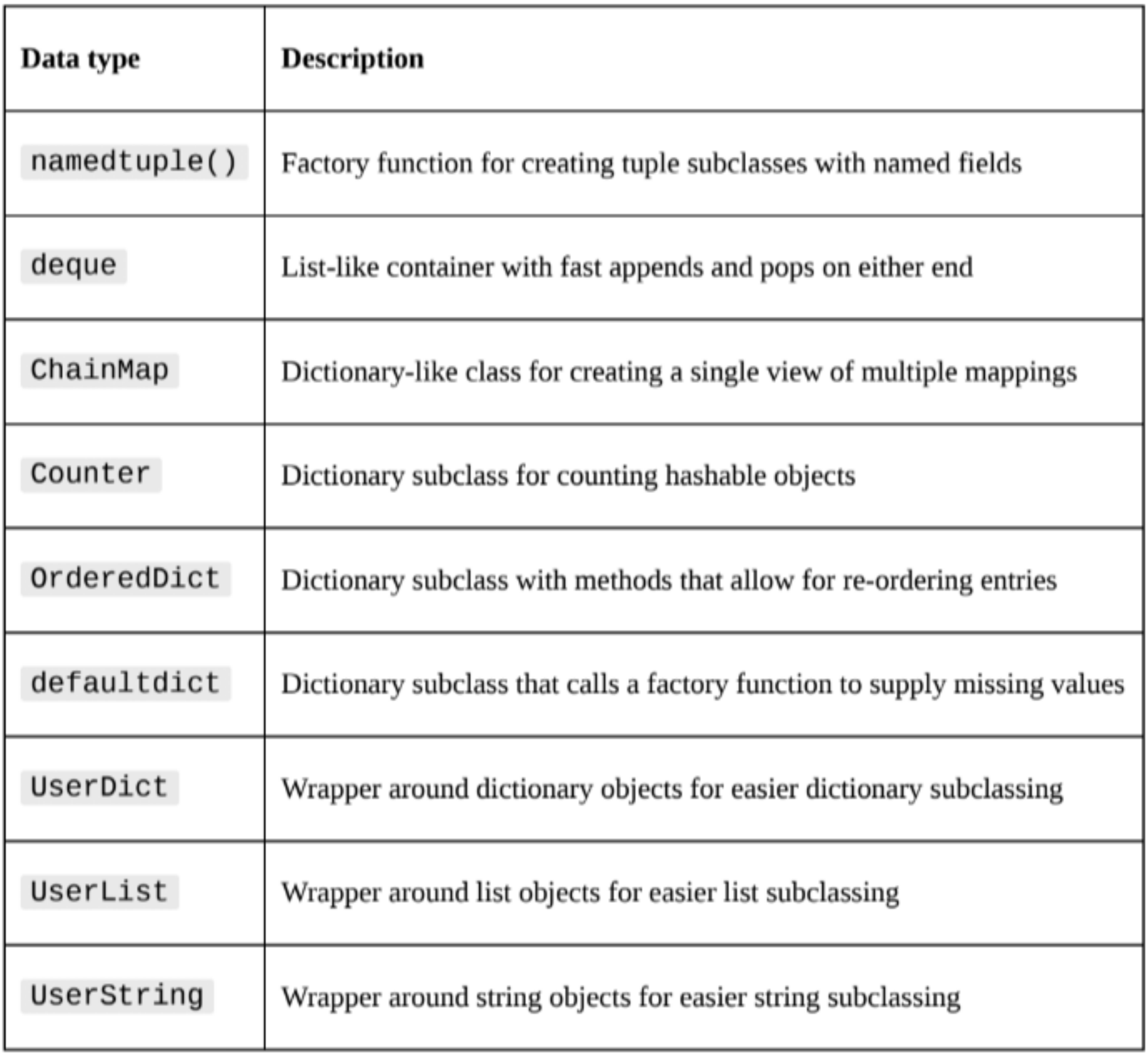
```
import arrow
arrow.utcnow()
# result: <Arrow [2022-12-20T13:46:42.122384+00:00]>

arrow.now()
# result: <Arrow [2022-12-20T08:48:42.621783-05:00]>

local = arrow.now('Europe/Rome')
local
# result: <Arrow [2022-12-20T14:49:50.028696+01:00]>

local.to('utc')
# result: <Arrow [2022-12-20T13:50:09.724853+00:00]>

local.to('Europe/Moscow')
# result: <Arrow [2022-12-20T16:50:09.724853+03:00]>

local.to('Asia/Tokyo')
# result: <Arrow [2022-12-20T22:50:09.724853+09:00]>

local.datetime
# result datetime.datetime(2022, 12, 20, 14, 50, 9, 724853,
tzinfo=tzfile('Arctic/Longyearbyen'))

local.isoformat()
# result '2022-12-20T14:50:09.724853+01:00'
```

  - Arrow provides a wrapper around the data structures of the standard library, plus a whole set of methods and helpers that simplify the task of dealing with dates and times. You can see from this example how easy it is to get the local date and time in the Italian time zone (Europe/Rome), as well as to convert it to UTC, or to the Russian or Japanese time zones. The last two instructions show how you can get the underlying **datetime** object from an Arrow one, and the very useful ISO-formatted representation of a date and time.

2.8.1.1 The collections module

• When Python general-purpose built-in containers (**tuple**, **list**, **set** and **dict**) aren't enough, we can find specialized container data types in the **collections** module:

◇



Data type	Description
`namedtuple()`	Factory function for creating tuple subclasses with named fields
`deque`	List-like container with fast appends and pops on either end
`ChainMap`	Dictionary-like class for creating a single view of multiple mappings
`Counter`	Dictionary subclass for counting hashable objects
`OrderedDict`	Dictionary subclass with methods that allow for re-ordering entries
`defaultdict`	Dictionary subclass that calls a factory function to supply missing values
`UserDict`	Wrapper around dictionary objects for easier dictionary subclassing
`UserList`	Wrapper around list objects for easier list subclassing
`UserString`	Wrapper around string objects for easier string subclassing

• There isn't enough space here to cover them all, but you can find plenty of examples in the official documentation; here, we will just give a small example to show you **namedtuple**, **defaultdict**, and **ChainMap**.

◇ **namedtuple**:

▪ It's a tuple-like object that has fields accessible by attribute lookup, as well as being **indexable** and **iterable** (it's actually a subclass of **tuple**). This is sort of a compromise between a fully-fledged object and a tuple, and it can be useful in those case where you don't need the full power of a custom object, but only want your code to be more readable by avoiding weird indexing. Another use case is when there is a chance that items in the tuple need to change their position after refactoring, forcing the coder to also refactor all the logic involved, which can be very tricky.

▪ For example, say we are handling data about the left and right eyes of a patient. We save one value for the left eye (position 0) and one for the right eye (position 1) in a regular tuple. Here's how that may look:

-
```
vision = (9.5, 8.8)
vision
# result: (9.5, 8.8)

vision[0]
# result: 9.5

vision[1]
# result: 8.8
```

→ Now let's pretend we handle vision objects all of the time, and, at some point, the designer needs to enhance them by adding information for the combined vision, so that a vision object stores data in this format (left eye, combined, right eye).

→ Do you see the trouble we're in now? We may have a lot of code that depends on **vision[0]** being the left eye information (which it still is) and **vision[1]** being the right eye information (which is no longer the case). We have to refactor our code wherever we handle these objects, changing **visi-on[1]** to **vision[2]**, and that can be painful. We could have probably approached this a bit better from the beginning, by using a **namedtuple**. Let us show you what we mean:

⇒

```
from collections import namedtuple
Vision = namedtuple('Vision', ['left', 'right'])
vision = Vision(9.5, 8.8)
vision[0]
# result: 9.5

vision.left # same as vision[0], but explicit
# result: 9.5

vision.right # same as vision[1], but explicit
# result: 8.8
```

• If, within our code, we refer to the left and right and eyes using **vision.left** and **vision. right**, all we need to do to fix the new design issue is change our factory and the way we create instances (the rest of the code won't need to change):

◇

```
Vision = namedtuple('Vision', ['left', 'combined', 'right'])
vision = Vision(9.5, 9.2, 8.8)
vision.left # still correct
# result: 9.5

vision.right # still correct
# result: 8.8
```

```
vision.right # still correct (though now is vision[2])
# result: 8.8

vision.combined # the new vision[1]
# result: 9.2
```

▪ You can see how convenient it is to refer to those values by name rather than by position. After all, as a wise man once wrote, Explicit is better than implicit. This example may be a little extreme; of course, it's not likely that our code designer will go for a change like this, but you'd be amazed to see how frequently issues similar to this one occur in a professional environment, and how painful it is to refactor in such cases.

◇ **defaultdict**:

▪ The **defaultdict** data type is one of the authors' favorites. **It allows you to avoid checking whether a key is in a dictionary by simply inserting it for you on your first access**, with a default value whose type you pass on creation. In some cases, this tool can be very handy and shorten your code a little. Let's see a quick example. Say we are updating the value of **age**, by adding one year. If **age** is not there, we assume it was and we update it to **1**:

```
d = {}
d['age'] = d.get('age', 0) + 1
d
# result: {'age': 1}

d = {'age': 39}
d['age'] = d.get('age', 0) + 1
d
# result: {'age': 40}
```

-

▪ Now let's see how it would work with the **defaultdict** data type. The second line is actually the short version of an **if** clause that runs to a length of four lines, and that we would have to write if dictionaries didn't have the **get()** method:

-

```
from collections import defaultdict
dd = defaultdict(int) # int is the default type (0 the value)
dd['age'] += 1 # short for dd['age'] = dd['age'] + 1
dd
# result: defaultdict(<class 'int'>, {'age': 1}) # 1, as expected
```

→ Notice how we just need to instruct the **defaultdict** factory that we want an **int** number to be used if the key is missing (we'll get **0**, which is the default for the **int** type).

→ Also notice that even though in this example there is no gain on the number of lines, there is definitely a gain in readability, which is very important. You can also use a different technique to instantiate a **defaultdict** data type, which involves creating a factory object.

◇ **ChainMap**:

▪ It's an extremely useful data type which was introduced in Python 3.3. It behaves like a normal dictionary but, according to Python documentation, is provided for quickly linking a number of mappings so they can be treated as a single unit. This is usually much faster than creating one dictionary and running multiple **update** calls on it. **ChainMap** can be used to simulate nested scopes and is useful in **templating**. The underlying mappings are stored in a list. That list is public and can be accessed or updated using the **maps** attribute. Lookups search the underlying mappings successively until a key is found. By contrast, writes, updates, and deletions only operate on the first mapping.

- A very common use case is providing defaults, so let's see an example:
  -

```
from collections import ChainMap
default_connection = {'host': 'localhost', 'port': 4567}
connection = {'port': 5678}
conn = ChainMap(connection, default_connection) # map creation
conn['port'] # port is found in the first dictionary
# result: 5678

conn['host'] # host is fetched from the second dictionary
# result: localhost

conn.maps # we can see the mapping objects
# result: [{'port': 5678}, {'host': 'localhost', 'port': 4567}]

conn['host'] = 'packtpub.com' # let's add host
conn.maps
# result: ['port': 5678, 'host': 'packtpub.com'],
{'host':'localhost', 'port': 4567}]

conn['port'] # now port is fetched from the second dictionary
# result: 4567

dict(conn) # easy to merge and convert to regular dictionary
# result: {'host': 'packtpub.com', 'port': 4567}
```

2.8.2 Enums

• Technically not a built-in data type, as you have to import them from the **enum** module, but definitely worth mentioning, are **enumerations**. They were introduced in Python 3.4, and though it is not that common to see them in professional code, we thought it would be a good idea to give you an example anyway.

• The official definition of an enumeration is that it is:

◇ A set of symbolic names (members) bound to unique, constant values. Within an enumeration, the members can be compared by identity, and the enumeration itself can be iterated over.

▪ Say that you need to represent traffic lights; in your code, you might resort to the following:

-

```
GREEN = 1
YELLOW = 2
RED = 4
TRAFFIC_LIGHTS = (GREEN, YELLOW, RED)

# or with a dict
traffic_lights = {'GREEN': 1, 'YELLOW': 2, 'RED': 4}
```

→ There's nothing special about this code. It's something, in fact, that is very common to find. But, consider doing this instead:

⇒

```
from enum import Enum

class TrafficLight(Enum):
    GREEN = 1
    YELLOW = 2
    RED = 4

TrafficLight.GREEN
# result: <TrafficLight.GREEN: 1>

TrafficLight.GREEN.name
# result: 'GREEN'

TrafficLight.GREEN.value
# result: 1

TrafficLight(1)
# result: <TrafficLight.GREEN: 1>

TrafficLight(4)
# result: <TrafficLight.RED: 4>
```

• Ignoring for a moment the (relative) complexity of a class definition, you can appreciate how this approach may be advantageous. The data structure is much cleaner, and the API it provides is much more powerful. We encourage you to check out the official documentation to explore all the great features you can find in the **enum** module. We think it's worth exploring at least once.

2.8.3 Final considerations

• That's it. Now you have seen a very good proportion of the data structures that you will use in Python.

• Before we leap into Chapter 3, we're gonna see some final considerations about different aspects that, to our minds, are important not to be neglected.

2.8.3.1 Small value caching

• **Small value caching**:

◇ While discussing objects at the beginning of this chapter, we saw that when we assigned a name to an object, Python creates the object, sets its value, and then points the name to it. We can assign different names to the same value, and we expect different objects to be created, like this:

▪
```
a = 1000000
b = 1000000
id(a) == id(b)
# result: False
```

- In the preceding example, **a** and **b** are assigned two **int** objects, which have the same value, but they are not the same object (as you can see, their **id** is not the same). So, let's do it again:

→
```
a = 5
b = 5
id(a) == id(b)
# result: True
```

⇒ Uh-oh! Is Python broken? Why are the two objects the same now? We didn't do **a = b = 5**; we set them up separately.

- Well, the answer is **performance**. Python caches short strings and small numbers to avoid having many copies of them clogging up the system memory. In the case of strings, caching or, more appropriately, interning them, also provides a significant performance improvement for comparison operations. Everything is handled properly under the hood, so you don't need to worry, but make sure that you remember this behavior should your code ever need to fiddle with IDs.

2.8.3.2 How to choose data structures

• **How to choose data structures**:

◇ As we've seen, Python provides you with several built-in data types and, sometimes, if you're not that experienced, choosing the one that serves you the best can be tricky, especially when it comes to collections. For example, say you have many dictionaries to store, each of which represents a customer. Within each customer dictionary, there's an **'id': 'code'** unique identification code. In what kind of collection would you place them? Well, unless we know more about these customers, it's very hard to answer.

▪ **What kind of access will we need?**

▪ **What sort of operations will we have to perform on each of them, and how many times?**

▪ **Will the collection change over time?**

▪ **Will we need to modify the customer dictionaries in any way?**

▪ **What is going to be the most frequent operation we will have to perform on the collection.**

◇ If you can answer the preceding questions, then you will know what to choose. If the collection never shrinks or grows (**in other words, it won't need to add/delete any customer object after creation**) or shuffles, then **tuples are a possible choice**.

◇ Otherwise, **lists are a good candidate**. **Every customer dictionary has a unique identifier though, so even a dictionary could work**. Let us draft these options for you:

▪

```
# example customer objects
customer1 = {'id': 'abc123', 'full_name': 'Master Yoda'}
customer2 = {'id': 'def456', 'full_name': 'Obi-Wan Kenobi'}
customer3 = {'id': 'ghi789', 'full_name': 'Anakin Skywalker'}

# collects them in a tuple
customers = (customer1, customer2, customer3)

# or collect them in a list
customers = [customer1, customer2, customer3]

# or maybe within a dictionary, they have a unique id after all
customers = {
    'abc123': customer1,
    'def456': customer2,
    'ghi789': customer3,
    }
```

- Some customers we have there right? We probably wouldn't go with the tuple option, unless we wanted to highlight that the collection is not going to change. We would say that, usually, a list is better, as it allows for more flexibility.

- Another factor to keep in mind is that tuple and lists are ordered collections. **If you use a dictionary (prior to Python 3.6) or a set**, **you would lose the ordering**, **so you need to know if ordering is important in your application**.

- What about performance? For example, in a **list**, operations such as insertion and membership testing can take O(n) time, while they are O(1) for a **dictionary**.

→ https://www.bigocheatsheet.com/

⇒ **It's not always possible to use dictionaries though**, **if we don't have the guarantee that we can uniquely identify each item of the collection by means of one of its properties, and that the property in question is hashable (so it can be a key in dict)**.

- Another way of understanding whether you have chosen the right data structure is by looking at the code you have to write in order to manipulate it.

→ **If everything comes easily and flows naturally, then you probably have chosen correctly, but if you find yourself thinking your code is unnecessarily complicated, then you probably should try to decide whether you need to reconsider your choices**.

⇒ it's quite hard to give advice without a practical case though, **so when you choose a data structure for your data, try to keep ease of use and performance in mind**, **and give precedence to what matters the most in the context you are in**.

2.8.3.3 About indexing and slicing

- At the beginning of this chapter, we saw slicing applied to strings.
    - Slicing, in general applies to a **sequence**: **tuples**, **lists**, **strings** and so on.
        - With lists, slicing can also be used for assignment. We have almost never seen this used in professional code, but still, you know you can. Could you slice dictionaries or sets? Of course not! Excellent, so let's talk about indexing.

- There is one characteristic regarding Python indexing that we haven't mentioned before. We'll show you by way of an example. How do you address the last element of a collection? Let's see:

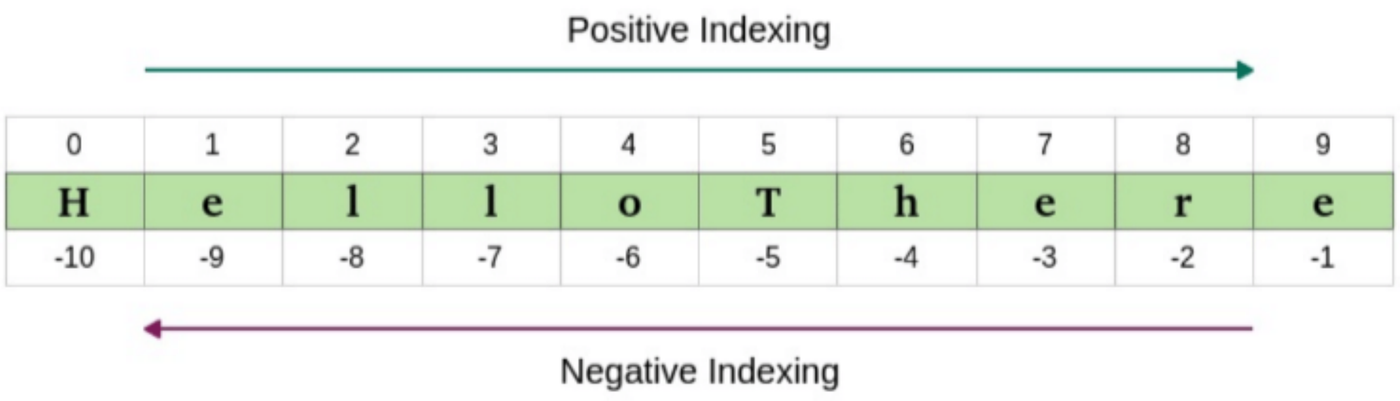
```
a = list(range(10)) # 'a' has 10 elements. Last one is 9.
a
# result: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

len(a) # its length is 10 elements
# result: 10

a[len(a) - 1] # position of last one is len(a) -1
# result: 9

a[-1]# but we don't need len(a)!
# result: 9

a[-2] # equivalent to len(a) - 2
# result: 8

a[-3] # equivalent to len(a) - 3
# result: 7
```

- **In order to fetch the last element, we need to know the whole length of the list (or tuple, or string, and so on) and then subtract 1**.

→ Hence: **len(a) - 1**.

⇒ This is so common an operation that Python provides you with a way to retrieve elements using **negative indexing**. This proves very useful when performing data manipulation. The following image shows how indexing works on the string "**HelloThere**":

→



2.8.3.4 About names

• You may have noticed that, in order to keep the examples as short as possible, we have named many objects using simple letters, like **a**, **b**, **c**, and so on. This is perfectly fine when debugging on the console or showing that **a + b == 7**, but it's bad practice when it comes to professional coding (or any type of coding, for that matter). We hope you will indulge us where we have done it; the reason is to present the code in a more compact way.

• In a real environment though, when you choose names for your data, you should choose them carefully (they should reflect what the data is about). So if you have a collection of **Customer** objects, **customers** is a perfectly good name for it. Would **customers_list**, **customers_tuple**, or **c-ustomers_collection** work as well? Think about it for a second. Is it good to tie the name of the collection to the datatype. We don't think so, at least in most cases. So, if you have an excellent reason to do so, go ahead; otherwise, don't. The reasoning behind this is that once **customers_tuple** starts being used in different places of your code, and you realize you actually want to use a list instead of a tuple, you're up for some fun refactoring (also known as wasted time). **Names for data should be nouns, and names for functions should be verbs**. Names should be as expressive as possible. Python is actually a very good example when it comes to names. Most of the time you can just guess what a function is called if you know what it does.

• Chapter 2 from the book Clean Code by Robert C. Martin is entirely dedicated to names. It's an amazing book that helped us to improve our coding style in many different ways; it is a must-read if you want to take your coding to the next level.

2.9 Summary

• We encourage you to Play with all data types. Exercise them, break them, discover all their methods, enjoy them, and learn them very, very well. **If your foundation is not rock solid, how good can your code be? Data is the foundation for everything; data shapes what dances around it**.

3. Conditionals and Iteration

- In this chapter, we are going to cover the following:
  - ◇ **Conditional programming**
  - ◇ **Looping in Python**
  - ◇ **Assignment expressions**
  - ◇ A quick peek at the **itertools** module.

3.1 Conditional programming

- **if** statement:
  - ◇
    ```
    late = True
    if late:
        print('I need to call my manager!')
    ```
    - Since **late** is **True**, the **print()** statement is executed. Let's expand on this example:
      -
        ```
        late = False
        if late:
            print('I need to call my manager!')
        else:
            print('No need to call my manager...')
        ```
        → this time set **late = False**, so when we execute the code, the result is different.

- **A specialized else: elif**
  - ◇ Let's take a look at an example with tax percentages:
    - If your income is less than **$10,000**, you **don't need to pay any taxes**.
    - If it is between **$10,000** and **$30,000**, you have to pay **20%** in taxes.
    - If it is between **$30,000** and **$100,000**, you pay **35%** in taxes, and if you're fortunate enough to earn over **$100,000**, you must pay **45%** in taxes. Let's put this all down into code:
      -

```
income = 15000
if income < 10000:
    tax_coefficient = 0.0
elif income < 30000:
    tax_coefficient = 0.2
elif income < 100000:
    tax_coefficient = 0.35
else:
    tax_coefficient = 0.45

print(f'You will pay: ${income * tax_coefficient} in taxes')
```

- Let's now see another example that shows us how to nest **if** clauses. Say your program encounters an error. If the alert system is the console, we print the error. If the alert system is an email, we send it according to the severity of the error. If the alert system is anything than console or email, we don't know what to do, therefore we do nothing. Let's put this into code:
  - ◇

```
alert_system = 'console' # other value can be 'email'
error_severity = 'critical' # other values: 'medium' or 'low'
error_message = 'Something terrible happened!'

if alert_system == 'console':
    print(error_message) # 1
elif alert_system = 'email':
```

```
    if error_severity == 'critical':
        send_email('admin@example.com', error_message) # 2
    elif error_severity == 'medium'
        send_email('support.1@example.com', error_message) # 3
    else:
        send_email('support.2@example.com', error_message) # 4
```

• **The ternary operator**:

◇ Short version of an **if** / **else** clause. When the value of a name is to be assigned according to some condition, it is sometimes easier and more readable to use the ternary operator instead of a proper **if** clause. For example, instead of:

```
order_total = 247

# classis if/else form
if order_total > 100:
    discount = 25
else:
    discount = 0
print(order_total, discount)

# tenary operator
discount = 25 if order_total > 100 else 0
print(order_total, discount)
```

▪

- For simple cases like this, we find it very convenient to be able to express that logic in one line instead of four. Remember, as a coder, you spend much more time reading code than writing it, so Python's conciseness is invaluable.

3.2 Looping

- If you have any experience with looping in other programming languages, you will find Python's way of looping a bit different. There are different looping constructs, which serve different purposes, and Python has distilled all of them down to just two, which you can use to achieve everything you need.
    - These are the statements:
        - **for**
            - and
        - **while**

- While it's definitely possible to do everything you need using either of them, they do serve different purposes, and therefore they're usually used in different contexts. We'll explore this difference thoroughly in this chapter.

3.2.1 The for loop

• The **for** loop **is used when looping over a sequence, such as a list, tuple, or collection of objects**. Let's start with a simple example and expand on the concept to what the Python syntax allows us to do:

◇
```
for number in [0, 1, 2, 3, 4]:
    print(number)
```

▪ This simple snippet of code, when executed, prints all numbers from **0** to **4**. The **for** loop is fed the list **[0, 1, 2, 3, 4]** and, at each iteration **number**, is given a value from the sequence (which is iterated sequentially in the order given), then the body of the loop is executed (the **print()** line).

▪ The **number** value changes at every iteration, according to which value is coming next from the sequence. When the sequence is exhausted, the **for** loop terminates, and the execution of the code resumes normally with the code after the loop.

• **Iterating over a range:**

◇ Sometimes we need to iterate over a range of numbers, and it would be quite unpleasant to have to do so by hard coding the list somewhere. in such cases, the **range()** function comes to the rescue. Let's see the equivalent of the previous snippet of code:

▪
```
for number in range(5):
    print(number)
```

- The **range()** function is used extensively in Python programs when it comes to creating sequences:

→ you call it by passing one value, which acts as **stop** (counting from **0**)

⇒ or you can pass two values (**start** and **stop**)

• or even three (**start**, **stop** and **step**).

◇ Let's take a look at an example:

▪

```
list(range(10)) # one value: from 0 to value (excluded)
# result: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

list(range(3, 8))
# result: [3, 4, 5, 6, 7]

list(range(-10, 10, 4))
# result: [-10, -6, -2, 2, 6]
```

▪ For the moment ignore that we need to wrap **range(...)** within a list. The **range()** object is a little special, but in this case, we are only interested in understanding what value it will return to us. You can see that the behavior is the same with slicing:

- **start** is included, **stop** is excluded, and optionally you can add a **step** parameter, which by default is **1**.

• **Iterating over a sequence:**

◇ We now have all the tools to iterate over a sequence, so let's build on that example:

```
surnames = ['Rivest', 'Shamir', 'Adleman']
for position in range(len(surnames)):
    print(position, surnames[position])
```

- Let's use the **inside-out** technique to break it down. We start from the innermost part of what we're trying to understand, and we expand outward.

→ So, **len(surnames)** is the length of the surname list: **3**. Therefore, **range(len(surnames)
)** is actually transformed into **range(3)**. This gives us the range **[0, 3)**
, which is basically the sequence **(0, 1, 2)**.

⇒ This means that the **for** loop will run three iterations. In the first one, **position** will take value **0**, while in the second one, it will take value **1**, and value **2** in the third and final iteration. What is **(0, 1, 2)**, if not the possible indexing positions for the **surnames** list? At position **0**, we find '**Rive-st**'; at position **1**, '**Shamir**'; and at position **2**, **'Adleman'**. If you are curious about what these three men created together together, change **print(position, surnames[position])** to **print(surnames[p-osition][0], end='')**, add a final **print()** outside of the loop, and run the code again.

```
surnames = ['Rivest', 'Shamir', 'Adleman']
for position in range(len(surnames)):
    #print(position, surnames[position])
    print(surnames[position][0], end='')
print()

# result: RSA
```

◇ Now, this style of looping is actually much close to languages such as Java or C. In Python, it's quite rare to see code like this. You can just iterate over any sequence or collection, so there is no need to get the list of positions and retrieve elements out of a sequence at each iteration. Let's change the example into a more Pythonic form:

```
surnames = ['Rivest', 'Shamir', 'Adleman']
for surname in surnames:
    print(surname)

# A more C like code:
#surnames = ['Rivest', 'Shamir', 'Adleman']
#for i in surnames:
#    print(i)
```

- Now that's something! It's practically English. The **for** loop can iterate over the **surnames** list, and it gives back each element in order at each iteration. Running this code will print the three surnames, one at a time, which is much easier to read.

◇ What if you wanted to **print the position as well**, though? Or what if you actually needed it? Should you go back to the **range(len(...))** form? No. You can use the **enumerate()** built-in function, like this:

```
#surnames = ['Rivest', 'Shamir', 'Adleman']
#for position, surname in enumerate(surnames):
```

```
#    print(position, surname)

# A more C like code:
surnames = ['Rivest', 'Shamir', 'Adleman']
for position, i in enumerate(surnames):
    print(position, i)
```

- This code is very interesting as well. Notice that **enumerate()** gives back a two tuple **(positi-on, surname)** at each iteration, but still, **it's much more readable (and more efficient)** than the **range(len(...))** example. You can call **enumerate()** with a start parameter, such as **enumerate(iter-able, start)** and it will start from **start**, rather than **0**.

3.2.2 Iterator and iterable

• You can use a **for** loop to iterate over lists, tuple, and in general anything that Python calls iterable. This is a very important concept, so let's talk about it a bit more.

• **Iterators and iterables**:

◇ According to the Python documentation an **iterable** is:

▪ "An object capable of returning its members one at a time. Examples of iterables include all sequence types (such as a **list**, **str** and **tuple**) and some non-sequence types like **dict**, **file objects**, and **objects** of any classes you define with an **__iter__()** method or with a **__getitem__()** method that implements Sequence semantics."

▪ Iterables can be used in a **for loop** and in many other places where a sequence is needed (**zip()**, **map()**, ...). When an iterable object is passed as an argument to the built-in function **iter()**, it returns an iterator for the object. This iterator is good for one pass over the set of values. When using iterables, it is usually not necessary to call **iter()** or deal with iterator objects yourself. The for statement does that automatically for you, creating a temporary unnamed variable to hold the iterator for the duration of the loop.

◇ Simply put, what happens when you write **for k in sequence: ... body ...** is that the **for** loop asks **sequence** for the next element, it gets something back, it calls that something **k**, and then executes its body. Then, once again, the **for** lop asks **sequence** for the next element, it calls it **k** again, and executes the body again, and so on and forth, until the sequence is exhausted. Empty sequences will result in zero executions of the body.

◇ Some data structures when iterated over, produce their elements in order, such as **lists**, **tuples**, **dictionaries**, and **strings**, while others, such as **sets**, **do not**. Python gives us the ability to iterate over iterable, using a type of object called an iterator.

◇ According to the official documentation, an iterator is:

▪ "An object representing a stream of data. Repeated calls to the iterator's **__next__()** method (or passing it to the built-in function **next()**) return successive items in the stream. When no more data is available a **StopIteration** exception is raised instead. At this point, the iterator object is exhausted and any further calls to its **__next__()** method just raise **StopIteration** again. Iterators are required to have an **__iter__()** method that returns the iterator object itself so every iterator is also iterable and may be used in most places where other iterable are accepted. One notable exception is code which attempts multiple iteration passes. A container object (such as a list) produces a fresh new iterator each time you pass it to the **iter()** function or use it in a for loop. Attempting this with an iterator will just return the same exhausted iterator object used in the previous iteration pass, making it appear like an empty container."

- Don't worry if you do not fully understand all the preceding legalese, as you will in due course. We have put it here to serve as a handy reference for the future

▪ In practice, the whole **iterable/iterator** mechanism is somewhat hidden behind the code. Unless you need to code your own iterable or iterator for some reason, you won't ave to worry about this too much. But it's very important to understand how Python handles this key aspect of control flow, because it will shape the way in which you write code.

• **Iterating over multiple sequences**:

◇ Let's see another example of how to iterate over two sequences of the same length, in order to work on their respective elements in pairs. Say we have a list of people and a list of numbers representing the age of the people in the first list. We want to print the pair **person**/**age** on one line for each of them. Let's start with an example, which we will refine gradually:

▪
```python
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
for position in range(len(people)):
    person = people[position]
    age = ages[position]
    print(person, age)
```

▪ By now, this code should pretty straightforward for you to understand. We need to iterate over the list of positions (**0**, **1**, **2**, **3**) because we want to retrieve elements from two different lists. Executing it, we get the following:

-
```
Nick 23
Rick 24
Roger 23
Syd 21
```

→ The code works, but it's not very Pythonic. It's rather cumbersome to have to get the length of **people**, construct a **range**, and then iterate over that. For some data structures it may also be expensive to retrieve items by their position.

→ Wouldn't it be nice if we could use the same approach as for iterating over a single sequence? Let's try to improve it by using **enumerate()** :

⇒

```python
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
for position, person in enumerate(people):
    age = ages[position]
    print(person, age)
```

• That's better, but not perfect. And it's still a bit ugly. We're iterating properly on **people**, but we're still fetching **age** using positional indexing, which we want to lose as well.

◇ Well, no worries, Python gives you the **zip()** function, remember? Let's use it:

▪

```python
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
for person, age in zip(people, ages):
    print(person, age)
```

- Ah! So much better! Once again, compare the preceding the code with the first example. The reason we wanted to show this example is twofold. On the one hand, we wanted to give you an idea of how much shorter code in Python can be compared to other languages where syntax doesn't allow you to iterate over sequences or collections as easily. And on the other hand, and much more importantly, notice that when the **for** loop asks **zip(sequenceA, sequenceB)** for the next element, it gets back a tuple, not just a single object. It gets back a **tuple**, not just a single object. it gets back a tuple with as many elements as the number of sequences we feed to the **zip()** function.

→ Let's expand a little on the previous example in two ways, using example in two ways, using **explicit** and implicit **assignment**:

⇒

```
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
instruments = ['Drums', 'Keyboards', 'Bass', 'Guitar']
for person, age, instrument in zip(people, ages, instruments):
    print(person, age, instrument)
```

• In the preceding code we added the **instruments** list. Now that we feed three sequences to the **zip()** function, the for loop gets back a three-tuple at each iteration. Notice that the position of the elements in the tuple respects the position of the sequence in the **zip()** call. Executing the code will yield the following result:

◇

```
Nick 23 Drums
Rick 24 Keyboards
Roger 23 Bass
Syd 21 Guitar
```

◇ Sometimes, for reasons that may not be clear in a simple example such as the preceding one, you may want to explode the tuple within the body of the **for** loop. If that is your desire, it's perfectly possible to do so:

▪

```
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
instruments = ['Drums', 'Keyboards', 'Bass', 'Guitar']
for data in zip(people, ages, instruments):
    person, age, instrument = data
    print(person, age, instrument)
```

- It's basically doing what the **for** loop does automatically for you, but in some cases you may want to do it yourself. Here, the three-tuple **data** that comes from **zip(...)** is exploded within the body of the **for** loop into **three variables**: **person**, **age**, and **instrument**.

3.2.3 The while loop

• In the preceding pages, we saw the **for** loop in action. It's incredibly useful when you need to loop over a sequence or a collection. They key point to keep in mind, when you need to decide which looping construct to use, is that the **for** loop **is best suited in cases where you need to iterate over the elements of some container or other iterable object**.

• There are other cases though, when you just need to loop until some condition is satisfied, or even loop indefinitely until the application is stopped, such as cases where we don't really have something to iterate on, and therefore the **for** loop would be a poor choice. But fear not, for these cases, Python provides us with the **while** loop.

◇ The **while** loop is similar to the **for** loop in that they both loop, and at each iteration they execute a body of instructions. The difference is that the **while** doesn't loop over a sequence (it can, but you have to write the logic manually, which would make little sense as you would just use a **for** loop); rather, it loops as long as a certain condition is satisfied. When the condition is no longer satisfied, the loop ends.

- As usual, let's see an example that will clarify everything for us. We want to print the binary representation of a positive number. In order to do so, we can use a simple algorithm that divides by **2** until we reach 0 and collects the remainders. When we reverse the list of remainders we collected, we get the binary representation of the number we started with:

→

```
6 / 2 = 3 # (remainder: 0)
3 / 2 = 1 # (remaindeer: 1)
1 / 2 = 0 # (remainder: 1)
# List of remainders: 0, 1, 1.
# Reversed is 1, 1, 0, which is also the binary representation of 6:
110
```

◇ Let's write some code to calculate the binary representation for the **number 38**, **100111**:

▪

```
n = 39
remainders = []
while n > 0:
    remainder = n % 2 # remainder of division by 2
    remainders.append(remainder) # we keep track of remainders
    n //= 2 # we divided n by 2
remainders.reverse()
print(remainders)
```

- In the preceding code, we highlighted **n > 0**, which is the condition to keep looping. Notice how the code matched the algorithm we described: as long as **n** is greater than **0**, we divide by **2** and add the remainder to the list. At the end (when **n** has reached **0**) we reverse the list of **remainders** to get the binary representation of the original value of **n**.

→ We can make the code a little shorter (and more Pythonic), by using the **divmod()** function, which is called with a number and a divisor, and returns a tuple with the result of the integer division and its remainder. For example, **divmod(13, 5)** would return **(2, 3)**, and indeed **5 * 2 + 3 =**

13:

⇒

```
n = 39
remainders = []
while n > 0:
    n, remainder = divmod(n, 2)
    remainders.append(remainder)
remainders.reverse()
print(remainders)
```

• In the preceding code, we have reassigned **n** to the result of the division by **2**, along with the **remainder**, in one single line.

◇ Notice that the condition in a **while** loop is a condition to continue looping. If it evaluates to **Tr-ue**, then the body is executed and another evaluation follows, and so on, until the condition evaluates to **False**. When that happens, the loop is exited immediately without executing its body.

▪ If the condition never evaluates to **False**, the loop becomes a so-called **infinite loop**. Infinite loops are used, for example, when polling from network devices: you ask the socket whether there is any data, you do something with it if there is any, then you sleep for a small amount of time, and then you ask the socket again, over and over again, without ever stopping.

◇ Having the ability to loop over a condition, or to loop indefinitely, is the reason why the **for** loop alone is not enough, and therefore Python provides the **while** loop.

▪ **Note**: if you need the **binary representation** of a number, check out the **bin()** function.

◇ Just for fun, let's adapt one of the examples (**multiple_sequences.py**):

▪
```
people = ['Nick', 'Rick', 'Roger', 'Syd']
ages = [23, 24, 23, 21]
position = 0
while position < len(people):
    person = people[position]
    age = ages[position]
    print(person, age)
    position += 1
```

- In the preceding code, we have highlighted the **initialization** (position = 0), **condition** (position < len(people):) and **update** (position += 1) of the **position** variable, which makes it possible to simulate the equivalent **for** loop code by handling the iteration variable manually.

- Everything that can be done with a **for** loop can also be done with a **while** loop, even though you can see there is a bit of boilerplate you have to go through in order to achieve the same result. The opposite is also true, but unless you have a reason to do so, you ought to use the right tool for the job, and 99.9% of the time you'll be fine.

◇ So, to recap, use a **for** loop when you need to iterate over an iterable, and a **while** loop when you need to loop according to a condition being satisfied or not. If you keep in mind the difference between the two purposes, you will never choose the wrong looping construct.

3.2.4 The break and continue statements

• Let us now see how to alter the normal flow of a loop.

• **The break and continue statements:**

◇ According to the task at hand, sometimes you will need to alter the regular flow of a loop. You can either skip a single iteration (as many times as you want), or you can break out of the loop entirely. A common use case for skipping iteration is, for example, when you are iterating over a list of items and you need to work on each of them only if some condition is verified. On the other hand, if you're iterating over a collection of items, and you have found one of them that satisfies some need you have, you may decide not to continue the loop entirely and therefore break out of it. There are countless possible scenarios, so it's better to take look at a couple of examples.

◇ Let's say you want to apply a 20% discount to all products in a basket list for those that have an expiration date of today. The way you achieve this is to use the **continue** statement, which tells the looping construct (**for** or **while**) to stop execution of the body immediately and go to next iteration, if any. This example will take us a little deeper down the rabbit hole, so be ready to jump:

▪

```
from datetime import date, timedelta

today = date.today()
tomorrow = today + timedelta(days=1) # today + 1 day is tomorrow

products = [
    {'sku': '1', 'expiration_date': today, 'price': 100.0},
    {'sku': '2', 'expiration_date': tomorrow, 'price': 50},
    {'sku': '3', 'expiration_date': today, 'price': 20},
]


#  for product in products:
#      if product['expiration_date'] != today:
#          continue
#      product['price'] *= 0.8 # equivalent to applyong 20% discount
#      print(
#          'Price for sku', product['sku'],
#          'is now', product['price'])

for i in products:
    if i['expiration_date'] != today:
        continue
    i['price'] *= 0.8
    print(
        'Price for sku', i['sku'],
        'is now', i['price'])
```

- We start by importing the **date** and **timedelta** objects, then we set up our products. Those with **sku** as **1** and **3** have an expiration date of **today**, which means we want to apply a **20%** discount on them. We loop over each product and inspect the expiration date. If it is not **today**, we don't want to execute the rest of the body suite, so we **continue**.

- Notice that it is not important where in the body suite you place the **continue** statement (you can even use it more than once). When you reach it, execution stops and goes back to the next iteration. The output would be the following:

→

```
Price for sku 1 is now 80.0
Price for sku 3 is now 16.0
```

⇒ This shows us that the last two lines of the body haven't been executed for **sku** number **2**.

◇ Let's now see an example of breaking out of a loop. Say we want to tell whether at least one of the elements in a list evaluates to **True** when fed to the **bool()** function. Given that we need to know whether there is at least one, when we find it, we don't need to keep scanning the list any further. In Python code, this translates to using the **break** statement. Let's write this down into code:

▪

```
items = [0, None, 0.0, True, 0, 7] # True and 7 evaluate to True
found = False # this is a flag

#  for item in items:
#      print('scanning item', item)
#      if item:
#          found = True # we update the flag
#          break
#  if found:    # we inspect the flag
#      print('At least one item evaluates to True')
#  else:
#      print('All items evaluate to False')

for i in items:
    print('scanning item', i)
    if i:
        found = True # we update the flag
        break
if found: # we inspect the flag
    print('At least one item evaluates to True')
else:
    print('All items evaluate to False')
```

- The preceding code makes use of a very common programming pattern; you set up a **flag** variable before starting the inspection of the items. If you find an element that matches your criteria (in this example, that evaluates to **True**), you update the flag and stop iterating. After iteration, you inspect the flag and action accordingly. Execution yields:

→

```
scanning item 0
scanning item None
scanning item 0.0
scanning item True
At least one item evaluates to True
```

⇒ See how execution stopped after **True** was found? The **break** statement acts exactly like the continue one, in that it stops executing the body of the loop immediately, but it also prevents any further iterations from running, effectively breaking out of the loop. The **continue** and **break** statements can be used together with no limitation in their numbers, both in the **for** and **while** looping constructs.

• **Note**: There is no need to write code to detect whether there is at least one element in a sequence that evaluates to **True**. Just check out the built-in **any()** function.

3.2.5 A special else clause

• One of the features we've seen only in the Python language is the ability to have clauses after **while** and **for** loops. It's very rarely used, but it's definitely useful to have. In short, you can have an **else** suite after a **for** or **while** loop. If the loop ends normally, because of exhaustion of the iterator (**for** loop) or because the condition is finally not met (**while** loop), then the **else** suite (if present is executed). If execution is interrupted by a break statement, the **else** clause is not executed.

• Let's take an example of a **for** loops that iterates over a group of items, looking for one that would match some condition, we want to raise an **exception**. This means that we want to arrest the regular execution of the program and signal that there was an error, or exception, that we cannot deal with. Exceptions basically alter the regular flow of the code.

• Let's see two example that do exactly the same thing, but one of them is using the special **for ... else** syntax. Say that we want to find, among a collection of people, one that could drive a car:

◇

```
class DriverException(Exception):
    pass
people = [('James', 17), ('Kirk', 9), ('Lars', 13), ('Robert', 8)]
driver = None
for person, age in people:
    if age >= 18:
        driver = (person, age)
        break
    if driver is None:
        raise DriverException('Driver not found.')
```

▪ Notice the flag pattern again. we set the driver to be **None**, then if we find one, we update the **driver** flag, and then, at the end of the loop, we inspect it to see whether one was found. Notice that if a driver is not found, **DriverException** is raised, signaling to the program that the execution cannot continue (we're lacking the driver).

- The same functionality can be rewritten a bit more elegantly using the following code:

→

```
class DriverException(Exception):
    pass
people = [('James', 17), ('Kirk', 9), ('Lars', 13), ('Robert', 8)]
for person, age in people:
    if age >= 18:
        driver = (person, age)
        break
else:
    raise DriverException('Driver not found.')
```

⇒ Notice that we are not forced to use the flag pattern any more. The exception is raised as part of the **for** loop logic, which makes good sense, because the **for** loop is checking on some condition. All we need is to set up a **driver** object in case we find one, because the rest of the code is going to use that information somewhere. Notice the code is shorter and more elegant because the logic is now correctly grouped together where it belongs.

• **Note**: In his Transforming **Code into Beautiful, Idiomatic Python** video, Raymond

Hettinger suggests a much better name for the **else** statement associated with a **for** loop: **nobreak**. If you struggle with remembergin how the else works for a **for** loop, simply remembering this fact should help you.

3.3 Assignment expressions

• Before we look at some more complicated examples, we would like to briefly introduce you to a relatively new feature that was added to the language in Python 3.8. Assignment expressions allow us to bind value to a name in places where normal assignment statements are not allowed. Instead of the normal assignment operator **=**, assignment expressions use := (know as the **walrus operator** because it resembles the eyes and tusks of a walrus)

• **Statements and expressions**:

◇ To understand the difference between normal assignments and assignment expression, we need to understand the difference between statements and expression. According to the Python documentation (https://docs.python.org/3/glossary.html), a **statement** is:

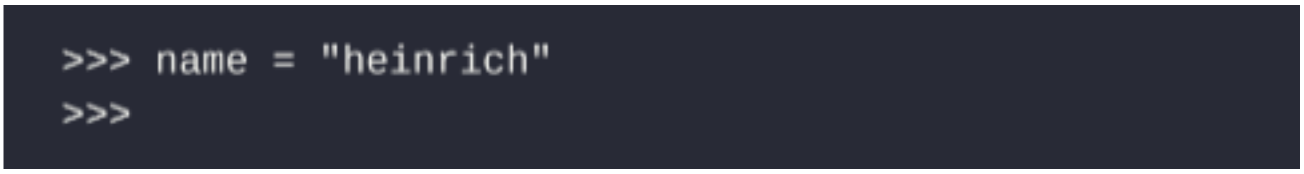
▪ " ...part of a suite (a "block" of code). A statement is either an expression or one of several constructs with a keyword, such as if, while or for. "

◇ An **expression** on the other hand, is:

▪ A piece of syntax which can be evaluated to some value. In other words, an expression is an accumulation of expression elements like literal, names, attribute access, operators or function call which all return a value.

◇ **The key distinguishing feature of an expression is that it has a return value**. Notice that . Notice that an expression can be a statement, but not all statements are expressions. In particular, assignments like **name = "heirich"** are not expression, and so do not have a return value. This means that you cannot use an assignment statement in the conditional expression of a **while** loop or **if** statement (or any other place where a value is required).

▪ Have you ever wondered why the Python console doesn't have a print value when you assign a value to a name? For example:

- 

```
>>> name = "heinrich"
>>>
```

→ Well, now you know! It's because what you've entered is a statement, which doesn't have a return value to print.

3.3.1 Using the walrus operator

- **Using the walrus operator:**

  ◇ Without assignment expressions, you would have to use two separate statements if you want to bind a value to a name and use that value in an expression. For example, it is quite common to see code similar to:

  ▪

```
remainder = value % modulus
if remainder:
    print(f"Not divisble! The remainder is {remainder}.")

# With assignment expressions, we could rewrite this as:
if remainder := value % modulus:
    print(f"Not divisble! The remainder is {remainder}.")
```

- Assignment expressions allow us to write fewer lines of code. Used with care, they can also lead to a cleaner, more understandable code. Let's look at a slightly bigger example to see how an assignment expression can really simplify a **while** loop.

  ◇ In interactive scripts, we often need to ask the user to choose between a number of options. For example, suppose we are writing an interactive script that allows customers at an ice cream shop to choose what flavor they want. To avoid confusion when preparing orders, we want to ensure that the user chooses one of the available flavors. Without assignment expression, we might write something like this:

  ▪

```
flavors = ["pistachio", "malaga", "vanilla", "chocolate",
"strawberry"]
prompt = "Choose your flavor: "
print(flavors)
while True:
    choice = input(prompt)
    if choice in flavors:
        break
    print(f"Sorry, '{choice}', is not a valid option.")
print(f"You chose '{choice}'")
```

- Take a moment to read this code carefully. Notice the condition on that loop: **while True** means "loop forever". That's not what we really want, is it? We want to stop looping when the user inputs a valid flavor (**choice in flavors**). To achieve that, we've used an **if** statement and a **break** inside the loop. The logic to control the loop is not immediately obvious. In spite of that, this is actually quite a common pattern when the value needed to control the loop can only be obtained inside the loop.

→ The **input()** function is very useful in interactive scripts. It allows you to prompt the user for input, and return it as a string. You can read more about it in the official Python documentation.

  ◇ How can we improve on the previous code? Let us try to use an assignment expression:

  ▪

```
flavors = ["pistachio", "malaga", "vanilla", "chocolate",
"strawberry"]
prompt = "Choose your flavor: "
print(flavors)
while (choice := input(prompt)) not in flavors:
    print(f"Sorry, '{choice}' is not a valid option.")
print(f"You chose, '{choice}'.")
```

- Now the loop's conditional expression says exactly what we want. That is much easier to understand. The code is also three lines shorter.

→ Note: Did you notice the parentheses around the assignment expression? We need them because the **:=** operator has lower precedence than the **not in** operator. Try removing the parentheses and see what happens.

◇ We have seen examples of using assignment expressions in the conditional expression of **if** and **while** statements. Besides these use cases, assignment expression are also very useful in lambda expre-ssions, as well as comprehensions and generators.

3.4 Putting all this together

• Now that you have seen all there is to see about conditionals and loops, it's time to spice up things a little, and look at those two examples we anticipated at the beginning of this chapter. We'll mix and match here, so you can see how you can use all these concepts together. Let's start by writing some code to generate a list of prime numbers up to some limit. Please bear in mind that we are going to a very inefficient and rudimentary algorithm to detect primes. The important thing is to concentrate on those bits in the code that belong to this chapter's subject.

• **A prime generator**:

◇ According to Wikipedia:

▪ "A **prime number** (or a **prime**) is a natural number greater than 1 that is not a product of two smaller natural numbers. A natural number greater than 1 that is not a prime is called a composite number. "

◇Based on this definition, if we consider the first 10 natural numbers, we can see that **2**, **3**, **5**, and **7** are primes, while **1**, **4**, **6**, **8**, **9**, and **10** are not. In order to have a computer tell you whether a number, N, is prime, you can divide that number by the natural numbers in the range [2, N}. If any of those divisions yields zero as a remainder, then the number is not a primer. We will write two version of this, the second of which will exploit the **for ... else** syntax:

▪

```
primes = [] # this will contain the primes at the end
upto = 100 # the limit, inclusive
for n in range(2, upto + 1):
    is_prime = True # flag, new at each iteration of outer for
    for divisor in range(2, n):
        if n % divisor == 0:
            is_prime = False
            break
    if is_prime: # check on flag
        primes.append(n)
print(primes)
```

- There are a lot of things to notice in the preceding code. First of all, we set up an empty **primes** list, which will contain the primes at the end. The limit is **100**, and you can see that it is inclusive in the way we call **range()** in the outer loop. If we wrote **range(2, upto)** that would be **[2, upto)**. Therefore **range(2, upto + 1)** gives us **[2, upto + 1)** = **[2, upto]**.

- So there are two **for** loops. In the outer one, we loop over the candidate primes (that is, all natural number from **2** to **upto**). Inside each iteration of this outer loop, we set up a flag (which is set to **True** at each iteration), and then start dividing the current value of **n** by all numbers from **2** to **n - 1**. If we find a proper divisor for **n**, it means **n** is composite, and therefore we the flag to **False** and break the loop. Notice that when we break the inner loop, the outer one keeps on going as normal. The reason why we break after having found a proper divisor for **n** is that we don't need any further information to be able to tell that **n** is not a prime.

- When we check on the **is_prime** flag, if it is still **True**, it means we couldn't find any number in [2, n) that is a proper divisor for **n**, therefore **n** is a prime. We append **n** to the **primes** list, and hop! Another iteration proceeds, until **n** equals **100**.

→ Running this code yields:

⇒

```
$ python primes.py
[2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61
,
67, 71, 73, 79, 83, 89, 97]
```

- Before proceeding, we will pose the following: of all the iterations of the outer loop, one of them is different from all the others. Can you tell which one this is and why?

- Did you figure it out? If not, don't feel bad; it's perfectly normal. We asked you to do it as a small exercise because this is what coders do all the time. The skill to understand what the code does by simply looking at it is something you build over time. It's very important, so try to exercise it whenever you can. The answer is: the iteration that behaves differently from all the others is the first one. The reason is that in the first iteration, **n** is **2**. Therefore the innermost **for** loop won't even run, because it's a **for** loop that iterates over **range(2, 2)**, and what is that if not **[2, 2)**? Try it out for yourself, write a simple **for** loop with that iterable, put a **print** in the body suite, and see whether anything happens.

◇ Now, from an algorithmic point of view, this code is inefficient; let's at least make it a bit easier on the eyes:

```
primes = []
upto = 100

for n in range(2, upto + 1):
    for divisor in range(2, n):
        if n % divisor == 0:
            break
    else:
        primes.append(n)
print(primes)
```

- Much better, right? the **is_prime** flag is gone, and we append **n** to the primes list when we know the inner **for** loop hasn't encountered any **breaks** statements. See how the code looks cleaner and reads better?

• **Applying discounts**:

◇ In this example we are going to see a technique that the authors are very fond of. In many programming languages, besides the **if** / **elif** / **else** constructs, in whatever form or syntax they may come, you can find another statement, usually called **switch** / **case**, that is not in Python. It is the equivalent of a cascade of **if** / **elif** / ... / **elif** / **else** clauses, with a syntax similar to this (we are using

JavaScript code here):

-

```
switch (day_number) {
    case 1:
    case 2:
    case 3:
    case 4:
    case 5:
        day = "Weekday";
        break;

    case 6:
        day = "Saturday";
        break;
    case 0:
        day = "Sunday";
        break;
    default:
        day = "";
        alert(day_number + ' is not a valid day number.')
}
```

- In the preceding code, we **switch** on variable called **day_number**. This means we get its value and then decide what case it fits in (if any). From **1** to **5** there is a cascade, which means no matter the number, **[1, 5]** all go down to the bit of logic that sets **day** as "**Weekday**". Then we have single cases for **0** and **6**, and a default case to prevent errors, which alerts the system that **day_numb-er** is not a valid number (that is, not in **[0, 6]**). Python is perfectly capable of realizing such logic using **if** / **elif** / **else** statements:

→

```
if 1 <= day_number <= 5:
    day = 'Weekday'
elif day_number == 6:
    day = 'Saturday'
elif day_number == 0:
    day = 'Sunday'
else:
    day = ''
    raise ValueError(
        str(day_number) + ' is not a valid day number.')
```

⇒ In the preceding code, we reproduce the same logic of the JavaScript snippet in Python using **if** / **elif** / **else** statements. We raise the **ValueError** exception just as an example at the end, if **day_number** is not in **[0, 6]**. This is one possible way of translating the **switch** / **case** logic, but there is also another one, sometimes called **dispatching**, which we will show you in the last version of the next example.

- **Note**: in Python you can make double (actually, even multiple) comparisons.

◇ Let's start the new example by simply writing some code that assigns a discount to customers based on their coupon value. We'll keep the logic down to a minimum bare (remember that all we care about is understanding conditionals and loops.):

▪

```python
customers = [
    dict(id=1, total=200, coupon_code='F20'), # F20: fixed, $20
    dict(id=2, total=150, coupon_code='P30'), # P30: percent, 30%
    dict(id=3, total=100, coupon_code='P50'), # P50: percent, 50%
    dict(id=4, total=110, coupon_code='F15'), # F15: fixed, $15
]

for customer in customers:
    code = customer['coupon_code']
    if code == 'F20':
        customer['discount'] = 20.0
    elif code == 'F15':
        customer['discount'] = 15.0
    elif code == 'P30':
        customer['discount'] = customer['total'] * 0.3
    elif code == 'P50':
        customer['discount'] = customer['total'] * 0.5
    else:
        customer['discount'] = 0.0
for customer in customers:
    print(customer['id'], customer['total'], customer['discount'])
```

- We start by setting up some customers. they have an order total, a coupon code, and an ID. We make up four different types of coupons: two are fixed and two are percentage-based. You can see that in the **if** / **elif** / **else** cascade we apply the discount accordingly, and we set it as a '**discount**' key in the **customer** dictionary.

→ At the end we just print out part of the data to see whether our code is working properly:

⇒

```
$ python coupons.py
1 200 20.0
2 150 45.0
3 100 50.0
4 110 15.0
```

• This code is simple to understand, but all those conditionals clauses are cluttering the logic. It's not easy to see what's going on at a first glance, which we don't like. In cases like this, you can exploit a dictionary to your advantage, like this:

◇

```python
customers = [
    dict(id=1, total=200, coupon_code='F20'), # F20: fixed, $20
    dict(id=2, total=150, coupon_code='P30'), # P30: percent, 30%
    dict(id=3, total=100, coupon_code='P50'), # P50: percent, 50%
    dict(id=4, total=110, coupon_code='F15'), # F15: fixed, $15
]

discounts = {
    'F20': (0.0, 20.0), # each valuen is (percent, fixed)
    'P30': (0.3, 0.0),
    'P50': (0.5, 0.0),
    'F15': (0.0, 15.0)
}

# for customer in customers:
#     code = customer['coupon_code']
#     percent, fixed = discounts.get(code,(0.0, 0.0))
#     customer['discount'] = percent * customer['total'] + fixed
# for customer in customers:
#     print(customer['id'], customer['total'], customer['discount'])


for i in customers:
    code = i['coupon_code']
    percent, fixed = discounts.get(code,(0.0, 0.0))
    i['discount'] = percent * i['total'] + fixed
for customer in customers:
    print(i['id'], i['total'], i['discount'])
```

▪ Running the preceding code yields exactly the same result we had from the snippet before it. We spared two lines, but more importantly, we gained a lot in readability, as the body of the **for** loop is now just three lines long, and very easy to understand. The concept here is to use a dictionary as a **dispatcher**. In other words, we try to fetch something from the dictionary based on a code (our **coupon_code**), and by using **dict.get(key, default)**, we make sure we also cater for when the **code** is not in the dictionary and we need a default value.

▪ Notice that we had to apply some very simple linear algebra in order to calculate the discount properly. Each discount has a **percentage** and **fixed part** in the dictionary, represented by a two-tuple. By applying **percent * total + fixed**, we get the correct discount. When **percent** is **0**, the formula just gives the fixed amount, and it gives **percent * total** when **fixed** is **0**.

▪ This technique is important, because it is also used in other contexts with functions where it becomes much more powerful than what we've seen in the preceding example. Another advantage of using it is that you can code it in such a way that the keys and values of the **discounts** dictionary are fetched dynamically (for example, from a database). This will allow the code to adapt to whatever discounts and conditions you have, without having to modify anything.

▪ If you are still unclear as to how this works, we suggest you take your time and experiment with it. Change values and add **print()** statements to see what's going on while the program is running.

3.5 A quick peek at the itertools module

• According to the Python official documentation (https://docs.python.org/3/library/itertools.html) the itertools module:

▪ " ... implements a number of iterator building blocks inspired by constructs from APL, Haskell and SML. Each has been recast in a form suitable for python. "

▪ "The module standardizes a core set of fast, memory efficient tools that are useful by themselves or in combination. Together, they form an ”iterator algebra" making it possible to construct specialized tools succinctly and efficiently in pure Python. "

• By no means do we have the room here to show you all the goodies you can find in this module, so we encourage you to go check it out for yourself. We can promise that you will enjoy it, though. In a nutshell, it provides you with three broad categories of iterators. We shall give you a very small example of one iterator taken from each one of them.

3.5.1 Infinte iterators

- **Infinite iterators**:
  - ◇ Infinite iterators allow you to work with a **for** loop in a different fashion, such as if it were a **whil-e** loop:
    - ▪

```
from itertools import count

for n in count(5, 3):
    if n > 20:
        break
    print(n, end=', ') # instead of newline, comma and space
```

- Running the code outputs:

→

```
$ python infinite.py
5, 8, 11, 14, 17, 20,
```

⇒ The **count** factory class makes an iterator that simply goes on and on counting. It starts from **5** and keeps adding **3** to it. We need to break it manually if we don't want to get stuck in an infinite loop.

3.5.2 Iterators terminating on the shortest input sequence

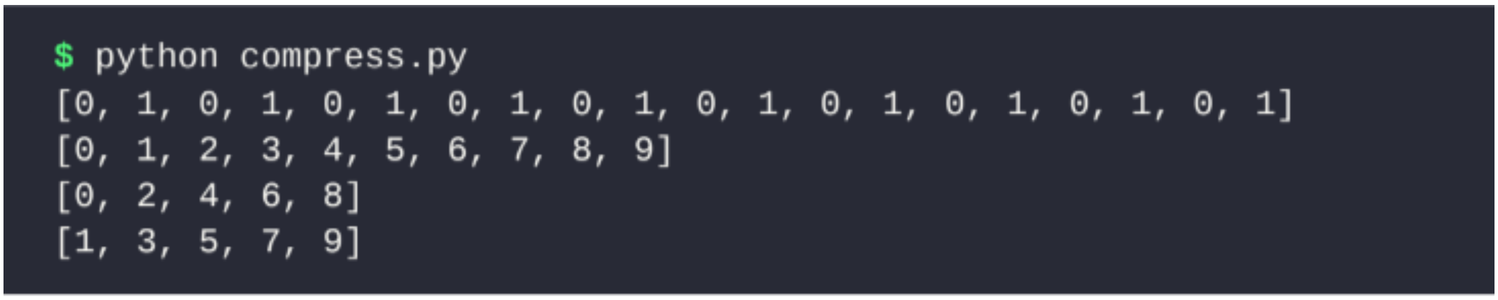
• This category is very interesting. It allows you to create an iterator based on multiple iterators, combining their values according to some logic. The key point here is that among those iterators, if any of them are shorter than the rest, the resulting iterator won't break, but simply stop as soon as the shortest iterator is exhausted. This is very theoretical, we know,so let us give you an example using **co-mpress()**. This iterator gives you back the data according to a corresponding item in a selector being **True** or **False**; **compress('ABC', (1, 0, 1))** would give back '**A**' and '**C**', because they correspond to **1**. Let's see a simple example:

▪

```
from itertools import compress

data = range(10)
even_selector = [1, 0] * 10
odd_selector = [0, 1] * 10
even_numbers = list(compress(data, even_selector))
odd_numbers = list(compress(data, odd_selector))

print(even_selector)
print(odd_selector)
print(list(data))
print(even_numbers)
print(odd_numbers)
```

- Notice that **odd_selector** and **even_selector** are 20 elements in length, while **data** is only **10**. **compress()** will stop as soon as **data** has yielded its last element. Running this code produces the following:

→



```
$ python compress.py
[0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1]
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
[0, 2, 4, 6, 8]
[1, 3, 5, 7, 9]
```

⇒ It's a very fast and convenient way of selecting elements out of an iterable. The code is very simple, but notice that instead of using a **for** loop to iterate over each value that is given back by the **compress()** calls, we used **list()**, which does the same, but instead of executing a body of instructions, it puts all the values into a list and returns it.

3.5.3 Combinatoric generators

• **Combinatoric generators**:

◇ Last but not least is combinatoric generators. These are really fun, if you are into this kind of thing. Let's look at a simple example on permutations. According to Wolfram MathWorld:

▪ "A permutation, also called an "arrangement number" or "order", is a rearrangemenet of the elements of an ordered list S into a one-to-one correspondence with S itself. "

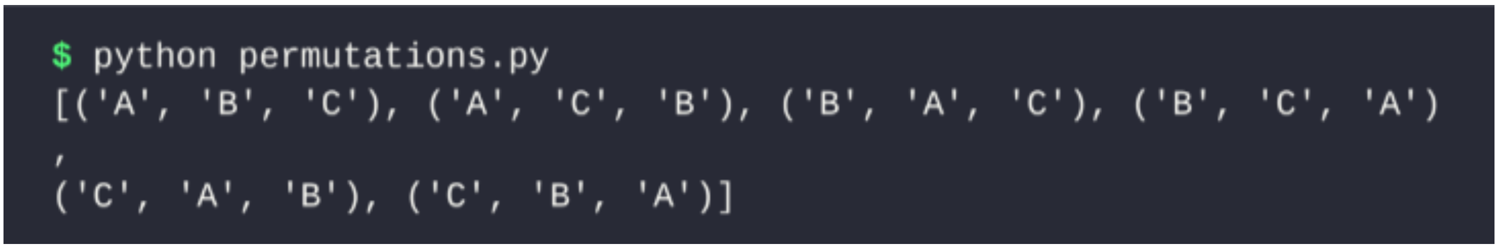
◇ For example, there are six permutations of **ABC**: **ABC**, **ACB**, **BAC**, **BCA**, **CAB**, and **CBA**.

◇ If a set has **N** elements, then the number of permutations of them is **N!** (N factorial). For the **ABC** string, the permutations are 3! = 3 * 2 * 1 = 6. Let's see this in Python:

▪
```
from itertools import permutations

print(list(permutations('ABC')))
```

- This very short snippet of code produces the following result:

→



```
$ python permutations.py
[('A', 'B', 'C'), ('A', 'C', 'B'), ('B', 'A', 'C'), ('B', 'C', 'A')
,
('C', 'A', 'B'), ('C', 'B', 'A')]
```

⇒ Be very careful when you play with permutations. Their number grows at a rate that is proportional to the factorial of the number of the elements you're permuting, and that number can get really big, really fast.

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4. Functions, the Building Blocks of Code